UNIVERSITI PUTRA MALAYSIA

ENHANCED INTERCROPPING PRODUCTIVITY OF SWEET CORN-OKRA IN YOUNG RUBBER PLANTATION

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By

SHAMPAZURAINI BINTI SAMSURI

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirement for the Degree of Doctor of Philosophy

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DEDICATION

Specially dedicated to my beloved husband, Mr. Azizul bin Aziz, my father, Mr. Samsuri bin Mohamad, my mother, Mrs. Halipah binti Thimin, my sons, Azaim Amsyar bin Azizul and Afahim Affan bin Azizul and also my beloved daughter, Azrhea Aileen binti Azizul for their endless love, sacrifices, support, understandings, motivation, advice and encouragement.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

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Chairman : Martini Mohammad Yusoff, PhD
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Rubber smallholders as a group is the most important player in the Malaysian rubber industry. During the early five year period, rubber smallholders have no source of income due to the long gestation period before the rubber trees can be tapped. However, rubber smallholders can generate income by practicing intercropping of rubber with food crops before the canopy closure of the rubber trees. In this regard, two seasons of field studies were conducted at the Rubber Research Institute of Malaysia Mini Station (RRIMINIS) Jasin, Melaka. The objectives were to evaluate the growth and yield performances, physiological characteristics, efficiency parameters and economic potential of sweet corn and okra intercropping planted in the young rubber plantation. Study 1 was carried out in November 2019 and the treatments were arranged in a randomized complete block design (RCBD) with three replications. The treatments comprised of five different sweet corn-okra intercropping ratios: T1 (20% okra + 80% sweet corn + rubber), T2 (50% okra + 50% sweet corn + rubber), T3 (80% okra + 20% sweet corn + rubber), T4 (100% okra + rubber) and T5 (100% sweet corn + rubber). Results on sweet corn revealed that the number of marketable cobs (31,999), cob yield (9,845 kg ha^{-1}) and biomass yield (32,816 kg ha^{-1}) were significantly influenced by the intercropping ratio where the highest value was obtained in sole sweet corn planting. Growth and yield of okra were significantly reduced when okra was intercropped with sweet corn. Maximum leaf area index (LAI_{max}) and maximum crop growth rate (CGR_{max}) showed significant difference of okra in all intercropping ratios but almost similar to sweet corn. The crop total intercepted photosynthetically active radiation (PAR) varied in different intercropping ratios and the highest was achieved by sole sweet corn and okra. For intercropping efficiency, the highest land equivalent ratio (LER) and monetary advantage index (MAI) were from the intercropping ratio of T1 with 1.14 and RM 3,388 ha^{-1}, respectively. Moreover, the economic analysis indicated that T1 also was the most profitable with the highest gross margin (RM 13,668.50 ha^{-1}). Study 2 was conducted in September 2020 at the same plot with a different intercropping system. The experimental design was RCBD with three replications. Intercropping ratio of 20% okra + 80% sweet corn was chosen from Study 1 and sole okra and sweet corn were used as controls. The study consisted of T1 (strips intercropping), T2 (strip relay intercropping), T3 (sole okra) and T4 (sole sweet corn). The highest yield of okra was obtained from strip relay intercropping when sweet corn was planted 4 weeks after okra. However, the economic analysis showed that strip intercropping recorded the maximum gross margin with RM 17,733.20 ha^{-1}. A highly significant difference was observed in the radiation use efficiency (RUE) of okra in all evaluated treatments. Strip intercropping not only resulted in the highest LER (1.29) but also area time equivalent ratio (ATER), % land saved and MAI with 1.14, 22.28% and RM 7,583.50 ha^{-1}, respectively compared with strip relay intercropping. Furthermore, strip intercropping indicated the lowest competitive ratio (CR). Intercropping of rubber trees with sweet corn and okra was beneficial in the early stages of rubber growth and did not have an adverse effect on the growth and development of young rubber trees. Result revealed that the girth increment rate of young rubber trees was significantly higher for young rubber trees grown in association with sweet corn-okra in an intercropping system than for those planted without intercropping. However, stem girth and average canopy diameter of young rubber trees were not significantly affected by either with or without sweet corn-okra intercropping. Thus, the intercropping ratio of 20% okra + 80% sweet corn + rubber and under strip intercropping system were proven to be the most effective systems and highest in profitability. Intercropping can provide early income and increase land-use efficiency without neglecting the growth performances and development of the main crop of rubber itself.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

MENINGKATKAN PRODUKTIVITI JAGUNG MANIS-BENDI SECARA SELINGAN DI PERLADANGAN GETAH MUDA

Oleh

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Pekebun kecil getah merupakan satu kumpulan pemain terpenting dalam industri getah Malaysia. Pada awal tempoh lima tahun pertama, pekebun kecil getah tidak mempunyai sumber pendapatan kerana tempoh matang yang lama sebelum pokok getah boleh ditoreh. Bagaimanapun, pekebun kecil getah boleh menjana pendapatan mereka dengan mengamalkan tanaman selingan untuk getah dengan tanaman makanan sebelum kanopi pokok getah membesar. Sehubungan itu, dua musim kajian lapangan telah dijalankan di Rubber Research Institute of Malaysia Mini Station (RRIMINIS) Jasin, Melaka. Objektif kajian adalah untuk menilai prestasi pertumbuhan dan hasil, ciri fisiologi, parameter kecekapan dan potensi ekonomi tanaman jagung manis dan bendi secara selingan di ladang getah muda. Kajian 1 telah dijalankan pada bulan November 2019 dan kajian dalam rekabentuk blok lengkap secara rawak (RCBD) dengan tiga replikasi. Lima nisbah tanaman selingan yang berbeza adalah terdiri daripada T1 (20% bendi + 80% jagung manis + getah), T2 (50% bendi + 50% jagung manis + getah), T3 (80% bendi + 20% jagung manis + getah), T4 (100% bendi + getah) dan T5 (100% jagung manis + getah). Keputusan pada jagung manis menunjukkan bahawa jumlah tongkol yang boleh dipasarkan (31,999), hasil tongkol (9,845 kg ha^{-1}) dan hasil biomas (32,816 kg ha^{-1}) dipengaruhi secara signifikan oleh nisbah tanaman selingan di mana nilai tertinggi diperoleh oleh jagung manis yang ditanam secara tunggal. Sementara itu, pertumbuhan dan hasil bendi berkurang dengan ketara apabila bendi ditanam secara selingan bersama jagung manis. Indeks luas daun maksimum (LAI_{max}) dan kadar pertumbuhan tanaman maksimum (CGR_{max}) bendi menunjukkan perbezaan yang signifikan dalam semua nisbah selingan tetapi hampir sama pada jagung manis. Jumlah persilangan radiasi aktif secara fotosintesis (PAR) pada tumbuhan adalah berbeza bagi setiap nisbah selingan dan pencapaian tertinggi adalah dari jagung manis dan bendi yang ditanam secara tunggal. Merujuk kepada kecekapan selingan, nisbah setara tanah (LER) dan indeks kelebihan wang (MAI) yang tertinggi adalah dari nisbah selingan T1, masing masing dengan 1.14 dan RM 3,388 ha^{-1}. Tambahan, analisis ekonomi menunjukkan bahawa nisbah T1 juga adalah yang paling menguntungkan dengan margin kasar yang lebih tinggi (RM 13,668.50 ha^{-1}). Oleh itu, nisbah selingan 20% bendi + 80% jagung

manis + getah adalah disyorkan kepada petani untuk di amalkan. Kajian 2 dilaksanakan pada bulan September 2020 di plot yang sama dengan sistem selingan yang berbeza. Rekabentuk kajian adalah RCBD dengan tiga replikasi. Nisbah 20% bendi + 80% jagung manis telah dipilih dari Kajian 1 manakala bendi tunggal dan jagung manis tunggal digunakan sebagai kawalan. Kajian ini terdiri daripada T1 (selingan jalur), T2 (selingan jalur berganti), T3 (bendi tunggal) dan T4 (jagung manis tunggal). Hasil tertinggi bendi diperolehi dari selingan jalur berganti apabila jagung manis ditanam 4 minggu selepas bendi. Walau bagaimanapun, analisis ekonomi menunjukkan bahawa selingan jalur mencatatkan margin kasar maksimum dengan nilai RM 17,733.20 ha^{-1}. Perbezaan yang sangat signifikan diperhatikan pada kecekapan penggunaan radiasi (RUE) bendi dalam semua rawatan yang dinilai. Selingan jalur tidak hanya menghasilkan LER tertinggi (1.29) tetapi juga nisbah setara masa kawasan (ATER), % tanah disimpan dan MAI dengan masing masing 1.14, 22.28% dan RM 7,583.50 ha^{-1} berbanding dengan selingan jalur berganti. Selanjutnya, selingan jalur menunjukkan nisbah persaingan (CR) yang terendah. Penanaman selingan pokok getah dengan jagung manis dan bendi telah memberi manfaat pada peringkat awal pertumbuhan getah dan tidak memberi kesan buruk kepada pertumbuhan dan perkembangan pokok getah muda. Keputusan kajian menunjukkan bahawa kadar peratusan lilitan batang pokok getah muda adalah lebih tinggi bagi pokok getah muda yang ditanam secara selingan bersama jagung manis-bendi berbanding dengan pokok yang ditanam tanpa selingan. Walau bagaimanapun, lilitan batang dan purata diameter kanopi pokok getah muda tidak terjejas sama ada dengan atau tanpa selingan jagung manis-bendi. Oleh itu, nisbah selingan 20% bendi + 80% jagung manis + getah dan di bawah sistem selingan jalur terbukti paling berkesan dan mempunyai keuntungan yang paling tinggi. Tanaman selingan boleh memberikan pendapatan awal dan meningkatkan kecekapan guna tanah tanpa mengabaikan prestasi pertumbuhan dan pembangunan tanaman utama getah itu sendiri.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

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Declaration by Members of Supervisory Committee

This is to confirm that:

- the research conducted and the writing of this thesis was under our supervision;
- supervision responsibilities as stated in the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) are adhered to.

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%	Percentage
°C	Degree celcius
μL	Microliter
a.i	Active ingredient
AI	Aggressivity index
Al	Aluminium
ANOVA	Analysis of variance
ATER	Area time equivalent ratio
AYL	Actual yield loss
B	Boron
BCR	Benefit-cost ratio
C	Carbon
Ca	Calcium
CEC	Cation exchange capacity
CGR_{max}	Maximum crop growth rate
cm	Centimeter
cmol	Centimoles
CR	Competitive ratio
d	Day
DAS	Days after sowing
DF	Degrees of freedom
Fe	Iron
Fi	Fraction of radiation intercepted
g	Gram
h	Hour
ha	Hectare
HI	Harvest index
IA	Intercropping advantage

K	Potassium
kg	Kilogram
L	Liter
LAI	Leaf area index
LAImax	Maximum leaf area index
LER	Land equivalent ratio
LSD	Least Significant Difference
m	Meter
M	Molar
MAI	Monetary advantage index
MARDI	Malaysian Agricultural Research and Development Institute
meq	Millequivalents
mg	Miligram
Mg	Magnesium
min	Minute
MJ	Megajoule
mL	Milliliter
mm	Millimeter
Mn	Manganese
MRB	Malaysia Rubber Board
MS	Mean Square
N	Nitrogen
Na	Sodium
Ni	Nickel
P	Phosphorus
PAR	Photosynthetically active radiation
pH	Scale of acidity
ppm	Parts per million
RM	Ringgit Malaysia

rpm	Revolutions per minute
RRIM	Rubber Research Institute of Malaysia
RRIMINIS	Rubber Research Institute of Malaysia Mini Station
RUE	Radiation use efficiency
s	Second
SAS	Statistical analysis system
SD	Standard deviation
SPI	System productivity index
St	Solar radiation
TDM	Total dry matter
USA	United State of America
var.	Variety
Zn	Zink
μ	Micro

CHAPTER 1

INTRODUCTION

1.1 Background of the study

Malaysia is the world's largest producer and exporter of rubber gloves, as well as one of the world's top exporters of condoms and catheters (Teresa, 2018). Such industries would be beneficial to Malaysia in terms of knowledge transfer, job creation, industry establishment, and innovation. Despite the great achievement in the production and market growth of rubber, rubber smallholders are still unable to earn adequate income at the early stage of rubber trees due to the rubber long gestation period.

The problem of lost income from the rubber crop especially during the replanting season can possibly be solved by introducing food crops in an intercropping system (Tetteh et al., 2019). Intercropping is defined as the agricultural practice of cultivating simultaneously two or more crops at the same time and in the same area (Hugar and Palled, 2008). Intercropping appears to be a viable practice to get extra income in rubber plantations during and beyond the early unproductive stage (Snoeck et al., 2013). Intercropping not only provides an additional source of income, but also aids in increasing food output and optimizing land use (Langert et al., 2006). Moreover, an intercropping system also improves the physicochemical properties of the soil (Esekhade et al., 2003).

Food crop is introduced because with increasing plantation area obviously it will reduce the land for agricultural activity in producing food locally. In fact, intercropping is generally observed within food crop production (Maitra et al., 2021). According to Juraimi (2018), there are five million hectares of land in Malaysia being cultivated with plantation crops, compared with just one million hectares for food crops.

Thus, intercropping practices could offer promising options to increase food crop production and meet the food demand of the human population in Malaysia. FAOSTAT (2022) stated that Malaysia's total population was 32.366 million people in 2020, however cereal and vegetable production decreased from year to year (Figure 1.1). In Malaysia for 2020, the production of cereal and vegetables were 2,389,843 tonnes and 556.789 tonnes, respectively.

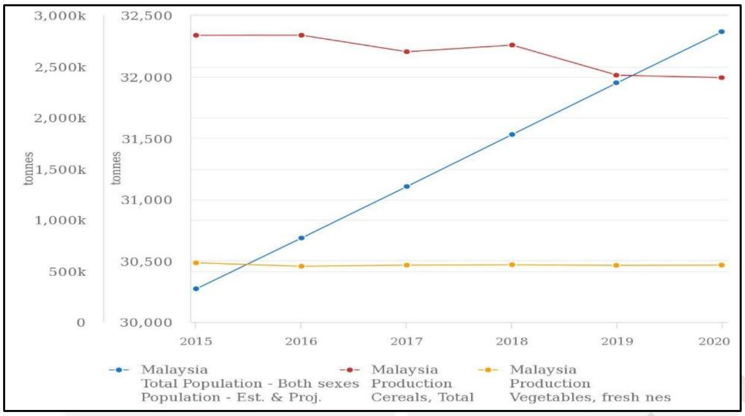

Figure 1.1 : Total of human population, vegetables and total production of cereals trends in Malaysia during 2015-2020
(Source : FAOSTAT, 2022)

In the light of the above scenario, more attention need to be given to the cereal and vegetable crops to increase their production in order to fulfill the domestic demand. Sweet corn is one of the crops commonly planted through intercropping with other food crops. Sweet corn (*Zea mays saccharata* Sturt.) consumption has risen dramatically all over the world, and it has traditionally being produced for human consumption in both fresh and processed forms. The demand for food and products made from corn has increased every year in Malaysia (Figure 1.2) with 605,000 tonnes of corn-based food products produced in 2019 according to FAOSTAT (2022) data. Sweet corn's nutrient profile is important for human health and nutrition. As a result, it is used as one of the principal sources of protein and energy in human diets in many parts of the world (Rouf Shah et al., 2016).

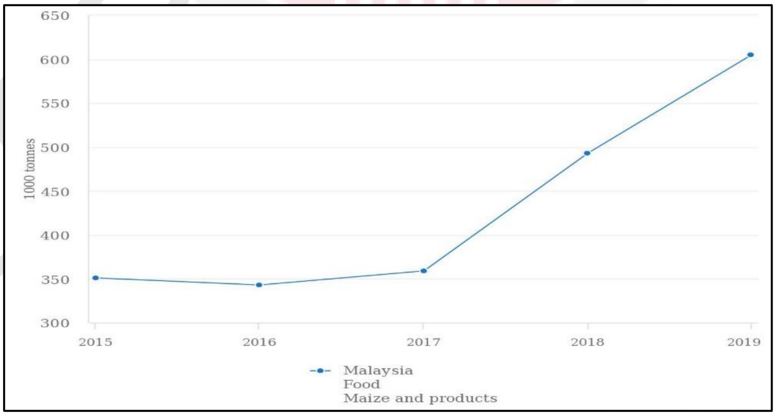

Figure 1.2 : Trend of food and products manufactured from maize in Malaysia between 2015 and 2019
(Source : FAOSTAT, 2022)

Other than sweet corn, okra is among the fruit vegetables commonly being intercropped with other crops. Okra (*Abelmoschus esculentus* (L) Moench) is an important vegetable crop that is grown and consumed throughout the world. Okra has several advantages over other vegetables because of its ability to produce fruits for a relatively long period and can be grown throughout the year with or without irrigation in the late season (Singh et al., 2014).

A study conducted on okra intercropping with other crops indicated several benefits such as yield advantages of 25-30% that higher in monetary *return* in the mixtures of okra-cassava (Muoneke and Mbah, 2007). An economic implication analysis showed that the profit from maize-okra intercropping was 10% higher than the sole cropping of both crops (Alabi and Esobhawan, 2006).

Different intercropping systems exist depending on crop selection and compatibility for the growing environment (Maitra, 2021). Cultivars, crop proportion and the competitive ability of crops also can affect the performance as well as the success of the intercropping systems. In view of these challenges, a comprehensive study of the intercropping system and crop ratio of sweet corn-okra developed in a young rubber plantation was studied. The study included four distinct crop ratios (100, 80:20, 50:50, 20:80) and three different intercropping systems (strip, strip relay and sole cropping). This intercropping system could have beneficial impacts on the rubber smallholders as well as improve crop productivity.

1.2 Research objectives

1.2.1 General objective

A study was conducted to examine the intercropping efficiency and economic potential of sweet corn - okra intercropping systems in a young rubber plantation area and their effects on the growth of young rubber trees.

1.2.2 Specific objectives

1) To determine the growth, physiological characteristics and yield performances of sweet corn- okra under different intercropping ratios and systems.
2) To measure the effect of different sweet corn-okra intercropping ratios and systems on the components of intercropping efficiencies (biological efficiencies, ecological efficiencies and economic efficiencies) in young rubber plantations.
3) To analyze the economic indicators of sweet corn-okra as affected by different intercropping ratios and systems in young rubber plantation.

4) To examine the growth performance of young rubber trees as affected by sweet corn-okra intercropping.

1.3 Justifications of research

The last few decades have brought remarkable development of the rubber crop as well as socio-economic transformation in Malaysia. Therefore, intercropping rubber with food crops will allow rubber smallholders to produce more than one crop in one area while also increasing land use efficiency, thus increasing farm income. In addition, this study will benefit the rubber smallholders as they can focus on generating income through the cultivation of food crops before the rubber trees reach the maturity stage for tapping. It may contribute to the fulfillment of the household food supply without neglecting the growth and yield performances of the main rubber crop itself.

REFERENCES

Addo-Quaye, A. A., Darkwa, A. A., and Ocloo, G. K. (2011). Growth analysis of component crops in a maize-soybean intercropping system as affected by time of planting and spatial arrangement. *ARPN Journal of Agricultural and Biological Science*, 6(6):34-44.

Agegnehu, G., Ghizaw, A., and Sinebo, W. (2008). Yield potential and land-use efficiency of wheat and faba bean mixed intercropping. *Agronomy for Sustainable Development*, 28:257-263.

Agegnehu, G., Ghizaw, A., and Sinebo, W. (2006). Yield performance and land-use efficiency of barley and faba bean mixed cropping in Ethiopian highlands. *European Journal of Agronomy*, 25(3):202–207.

Ahmad, A. H., Ahmad, R., Mahmood, N., and Tanveer, A. (2007). Performance of forage sorghum intercropped with forage legumes under different planting patterns. *Pakistan Journal of Botany*, 39:431-439.

Ahmadabad, Z. R., Meftahizadeh, H., Shirmardi, M., Ghorbanpour, M., and Ardakani, M. D. (2022). Intercropping improves yield and phytochemical attributes in guar (*Cyamopsis tetragonoloba* L.) and roselle (*Hibiscus sabdariffa* L.) plants under nitrogen application. *South African Journal of Botany*, 147:608-617.

Akanbi, W. B., Togun, A. O., Adediran, J. A., and Ilupeju, E. A. O. (2010). Growth, dry matter and fruit yields components of okra under organic and inorganic sources of nutrients. *American-Eurasian Journal of Sustainable Agriculture*, 4(1):1-13.

Alabi, R. A., and Esobhawan, A. O. (2006). Relative economic value of maize-okra intercrops in rainforest zone, Nigeria. *Journal of Central European Agriculture,* 7(3):433-438.

Ali, M. F. (2021). *Investigating the opportunities to improve smallholder rubber production through the development of an integrated decision support system: A Malaysian case study*. Ph.D Thesis, University of Queensland, Australia.

Almaz, M. G., Halim, R. A., and Martini, M. Y. (2017). Effect of combined application of poultry manure and inorganic fertiliser on yield and yield components of maize intercropped with soybean. *Pertanika Journal of Tropical Agricultural Science*, 40(1):173-184.

Altieri, M. A., Funes-Monzote, F. R., and Petersen, P. (2012). Agroecologically efficient agricultural systems for smallholder farmers: contributions to food sovereignty. *Agronomy for Sustainable Development*, 32(1):1-13.

Ananthi, T., Mohamed Amanullah, M., and Vennila, C. (2019). Economics of different intercropping systems of maize under mycorrhizal inoculation and different fertilizer levels. *Current Journal of Applied Science and Technology*, 37(2):1-10.

Andersen, M. K., Hauggaard-Nielsen, H., Høgh-Jensen, H., and Jensen, E. S. (2007). Competition for and utilization of sulfur in sole and intercrops of pea and barley. *Nutrients Cycling in Agroecosystem*, 77:143-153.

Andersen, M. K., Hauggaard-Nielsen, H., Ambus, P., and Jensen, E. S. (2005). Biomass production, symbiotic nitrogen fixation and inorganic N use in dual and tri-component annual intercrops. *Plant and Soil*, 266:273-287

Andrade, F. H., Calvino, P., Cirilo, A., and Barbieri, P. (2002). Yield responses to narrow rows depend on increased radiation interception. *Agronomy Journal*, 94:975-980.

Androcioli, H. G., Hoshino, A. T., Júnior, A. O. M., Morais, H., Bianco, R., and Caramori, P. H. (2018). Coffee leaf miner incidence and its predation bay wasp in coffee intercropped with rubber trees. *Coffee Science, Lavras*, 13(3):389 – 400.

Angombe, S. T., Shikangalah, R. N., Kwembeya, E. G., and Kanime, N. (2020). Potential for crown diameter as a predictor of canopy cover under National Park conditions. *African Crop Science Journal*, 28:305-317.

Anishkumar, P.T. (2014). Impact of price rise on poor households: a case study of Chirakkadavu Grama Panchayath, Kottayam, Kerala. *Language In India*, 14(6):25-31.

Arif, M., Kumar, A., and Pourouchottamane, R. (2022). Pearl millet and cluster bean intercropping for enhancing fodder productivity, profitability and land use efficiency. *Bangladesh Journal of Botany*, 51(1):103-112.

Armitage, H. M., Lane, D., and Webb, A. (2020). Budget development and use in small and medium-sized enterprises: A field investigation. *Accounting Perspectives*, 19(3):205-240.

Awal, M. A., and Khan, M. A. H. (2000). Mulch induced eco-physiological growth and yield of maize. *Pakistan Journal of Biological Sciences*, 3:61-64.

Awal, M. A., Koshi, H., and Ikeda, T. (2006). Radiation interception and use by maize-peanut intercrop canopy. *Agriculture Forest Meteorology*, 139:74-83.

Aynehband, A., and Behrooz, M. (2011). Evaluation of cereal-legume and cereal-pseudocereal intercropping systems through forage productivity and competition ability. *American-Eurasian Journal of Agriculture and Environmental Science*, 10:675-683.

Baghdadi, A., Halim, R. A., Othman, R., Yusof, M. M., and Atashgahi, A. R. M. (2016). Productivity, relative yield and plant growth of forage corn intercropped with soybean under different crop combination ratio. *Legume Research*, 39(4):558-564.

Baghdadi, A., Paknejad, F., Golzardi, F., Hashemi, M., and Ilkaee, M. N. (2021). Suitability and benefits from intercropped sorghum–amaranth under partial root-zone irrigation. *Journal of the Science of Food and Agriculture*, 101(14):5918-5926.

Bai, Z., Mao, S., Han, Y., Feng, L., Wang, G., Yang, B., Zhi, X., Fan, Z., Lei, Y., Du, W., and Li, Y. (2016). Study on light interception and biomass production of different cotton cultivars. *Plos One*, 11(5): e0156335.

Banik, P. (1996). Evaluation of wheat (*Triticum aestivum*) and legume intercropping under 1:1 and 2: 1 row-replacement series system. *Journal of Agronomy and Crop Science*, 176:289-294.

Banik, P., Midya, A., Sarkar, B. K., and Ghose, S. S. (2006). Wheat and chickpea intercropping systems in an additive series experiment: advantages and weed smothering. *European Journal of Agronomy*, 24:325-332.

Banik, P., Sasmal, T., Ghosal, P. K., and Bagchi, D. K. (2000). Evaluation of mustard (*Brassica compestris* Var. Toria) and legume intercropping under 1: 1 and 2: 1 row-replacement series systems. *Journal of Agronomy and Crop Science*, 185:9-14.

Bedoussac, L., and Justes, E. (2010) Dynamic analysis of competition and complementarity for light and N use to understand the yield and the protein content of a durum wheat–winter pea intercrop. *Plant Soil*, 330(1-2):37–54.

Bekele, D. (2021). Review on: Inter-cropping system and its advantages. *Reports*, 1(4): 36-42.

Bhatti, I. H., Ahmad, R., Jabbar, A., Nadeem, M., Khan, M. M., and Vains, S. N. (2013). Agronomic performance of mash bean as an intercrop in sesame under different planting patterns. *Emirates Journal of Food and Agriculture*, 25:52- 57.

Biabani, A., Hashemi, M., and Herbert, S. J. (2012). Agronomic performance of two intercropped soybean cultivars. *International Journal of Plant Production*, 2(3):215–222.

Bitew, Y., Derebe, B., Worku, A., and Chakelie, G. (2021). Response of maize and common bean to spatial and temporal differentiation in maize-common bean intercropping. *Plos One*, 16(10):e0257203.

Borghi, E., Crusciol, C. A. C., Nascente, A. S., Sousa, V. V., Martins, P. O., Mateus, G. P., and Costa, C. (2013). Sorghum grain yield, forage biomass production and revenue as affected by intercropping time. *European Journal of Agronomy*, 51:130-139.

Brintha, I., and Seran, T. H. (2009). Effect of paired row planting of raddish (*Raphanus sativus* L.) intercropped with vegetable amaranths (*Amaranths tricolor* L.) on yield components in sandy regosol. *The Journal of Agricultural Sciences*, 4:19-28.

Brooker, R. W., Bennett, A. E., Cong, W. F., Daniell, T. J., George, T. S., Hallett, P. D., Hawes, C., Iannetta, P. P. M., Jones, H. G., Karley, A. J., Li, L., McKenzie, B. M., Pakeman, R. J., Paterson, E., Schob, C., Shen, J., Squire, G., Watson, C. A., Zhang, C., Zhang, F., Zhang, J., and White, P. J. (2015). Improving intercropping: a synthesis of research in agronomy, plant physiology and ecology. *New Phytologist*, 206:107-117.

Burgess, A. J., Cano, M. E. C., and Parkes, B. (2022). The deployment of intercropping and agroforestry as adaptation to climate change. *Crop and Environment*, 1-52.

Bybee-Finley, K., and Ryan, M. R. (2018). Advancing intercropping research and practices in industrialized agricultural landscapes. *Agriculture*, 8(6):80-103.

Chaturvedi, A. K., Surendran, U., Gopinath, G., Chandran, K. M., Anjali, N. K., and Ct, M. F. (2019). Elucidation of stage specific physiological sensitivity of okra to drought stress through leaf gas exchange, spectral indices, growth and yield parameters. *Agricultural Water Management*, 222:92-104.

Chen, Z., Cui, H., Wu, P., Zhao, Y., and Sun, Y. (2010). Study on optimal intercropping width to control wind erosion in North China. *Soil and Tillage Research*, 110:230-235.

Choudhuri, P. (2011). *Growth, yield, quality and economic impacts of intercropping in vegetable and spice crops.* Ph.D. Thesis, Uttar Banga Kirishi Viswavidyalaya, India.

Choudhuri, P., and Jana, J. C. (2015). Growth, yield, quality and economic impacts of intercropping in potato. *Agricultural and Biological Sciences Journal*, 1(1):6-9.

Connolly, J., Goma, H. C., and Rahim, K. (2001). The information content of indicators in intercropping research. *Agriculture, Ecosystem Environment*, 87:191–207.

Cui, J., Yan, P., Wang, X., Yang, J., Li, Z., Yang, X., Sui, P., and Chen, Y. (2018). Integrated assessment of economic and environmental consequences of shifting cropping system from wheat-maize to monocropped maize in the North China Plain. *Journal of Cleaner Production*, 193:524-532.

Dahmardeh, M., Ghanbari, A., Syasar, B., and Ramroudi, M. (2009). Effect of intercropping maize (*Zea mays* L.) with cow pea (*Vigna unguiculate* L.) on green forage yield and quality evaluation. *Asian Journal of Plant Sciences*, 8(3):235-239.

Dangia, N., Jalata, Z., and Daba, G. (2021). Effects of varieties and population of soybean intercropped with maize on yield and yield components of associated crops. *Journal of Plant Sciences*, 9(4):128-138.

Das, G., Singh, R. S., Gohain, T., Meti, S., Chaudhuri, D., and Nazeer, M. A. (2008). Effect of rubber on intercropped tea during immature phase of rubber cultivation. *Natural Rubber Research*, 21(1-2):134-138.

Déo-Gratias, J. M., Hougni, B. C., Eric, P., and Arunee, P. (2018). The household economics of rubber intercropping during the immature period in Northeast Thailand. *Journal of Sustainable Forestry*, 37(8):787-803.

de Sa Souza, M., Junior, G. D. N. A., de Souza, L. S. B., Ferraz Jardim, A. M. D. R., da Silva, G. I. N., de Araujo, G. G. L., Campos, F. S., Leite, M. L. D. M. V., Tabosa, J. N., and Silva, T. G. F. D. (2022). Forage yield, competition and economic benefit of intercropping cactus and millet with mulch in a semi-arid environment. *African Journal of Range and Forage Science*, 1-12.

Dhima, K. V., Lithourgidis, A. S., Vasilakoglou, I. B., and Dordas, C. A. (2007). Competition indices of common vetch and cereal intercrops in two seeding ratio. *Field Crops Research*, 100: 249-256.

Dhima, K. V., Vasilakoglou, I. B., Keco, R. X., Dima, A. K., Paschalidis, K. Á., and Gatsis, T. D. (2014). Forage yield and competition indices of faba bean intercropped with oat. *Grass and Forage Science*, 69:376-383.

Dikr, W., and Abayechaw, D. (2021). Evaluating agronomic and essential oil of african marigold (*Tagetes erecta* L.) varieties intercropping with tomato by its population density at Wondo Genet, Southern Ethiopia. *Agriculture, Forestry and Fisheries*, 10(6):220-233.

Diver, S., Kuepper, G., Sullivam, P., and Adam, K. (2008). Sweet corn: organic production. *National Sustainable Agriculture Information Service*, 6:1-24.

Dordas, C. A., Vlachostergios, D. N., and Lithourgidis, A. S. (2012). Growth dynamics and agronomic-economic benefits of pea–oat and pea–barley intercrops. *Crop Pasture Sciences*, 63 (1):45–52.

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*, 11:178-185.

Doye, D. G. (2020). Budgets: Their use in farm management. *Oklahoma Cooperative Extension Service*. Oklahoma State University, USA.

Doye, D. G., and Sahs, R. (2016). Using enterprise budgets in farm financial planning. *Oklahoma Cooperative Extension Service*. Oklahoma State University, USA.

Dua, V. K., Kumar, S., and Jatav, M. K. (2017). Effect of nitrogen application to intercrops on yield, competition, nutrient use efficiency and economics in potato (*Solanum tuberosum* L.) + French bean (*Phaseolus vulgaris L.)* system in north-western hills of India. *Legume Research-An International Journal*, 40(4):698-703.

Duan, S. B., Li, Z. L., Wu, H., Tang, B. H., Ma, L., Zhao, E., and Li, C. (2014). Inversion of the PROSAIL model to estimate leaf area index of maize, potato, and sunflower fields from unmanned aerial vehicle hyperspectral data. *International Journal of Applied Earth Observation and Geoinformation*, 26:12-20.

Echarte, L., Della Maggiora, A., Cerrudo, D., Gonzalez, V. H., Abbate, P., Cerrudo, A., Sadras, V. O., and Calvino, P. (2011). Yield response to plant density of maize and sunflower intercropped with soybean. *Field Crops Research*, 121(3):423-429.

Egbe, O. M., Alibo, S. E., and Nwueze, I. (2010). Evaluation of some extra early and early maturing cowpea varieties for intercropping with maize in southern Guinea Savanna of Nigeria. *Agriculture and Biology Journal of North America*, 1(5):845-858.

Elmore, R. W., Marx, D. B., Klein, R. G., and Abenroth, L. J. (2005). Wind effect on corn leaf azimuth. *Crop Science*, 45:2598-2604.

Esekhade, T. U., Idoko, S. O., Osazuwa Okore, I. K., and Mesike, C. S. (2014). Effect of intercropping on the gestation period of rubber. *Wudpecker Journal of Agricultural Research*, 3(8):150-153.

Esekhade, T. U., Orimoloye, J. R., Ugwa, I. K., and Idoko, S. O. (2003). Potentials of multiple cropping systems in young rubber plantations. *Journal of Sustainable Agriculture*, 22(4):79-94.

Esekhade, T. U., and Ugwa, I. K. (2000). Reducing the immaturity period of rubber in a rubber-cooking banana intercrop on an acid sandy soil of southern Nigeria. *MusAfrica*, 14:11-17.

FAOSTAT (2022). Food and agriculture organization of the United Nations. Retrieved from: https://www.fao.org/faostat/en/ #compare/ (Assessed June 25, 2022).

Fox, J., and Castella, J. C. (2013). Expansion of rubber (*Hevea brasiliensis*) in Mainland Southeast Asia: What are the prospects for smallholders? *The Journal of Peasant Studies*, 40:155–170.

Gallagher, J. N., and Biscoe, P. V. (1978). Radiation absorption, growth and yield of cereals. *Journal of Agricultural Science*, 91:47-60.

Gao, Y., Duan, A. W., Qiu, X. Q., Liu, Z. G., Sun, J. S., and Zhang, J. P. (2010). Distribution and use efficiency of photosynthetically active radiation in strip intercropping of maize and soybean. *Agronomy Journal*, 102:1149–1157.

Gebru, H. (2015). A review on the comparative advantage of intercropping systems. *Journal of Biology, Agriculture and Healthcare*, 5(9):28-38.

Geetha, P., Tayade, A. S., Arun Kumar, R., and Rajesh, K. (2019). Light interception in sugarcane based intercropping system. *Journal of Agrometeorology*, 21(2):210-212.

Geren, H., Avcioglu, R., Soya, H., and Kir, B. (2008). Intercropping of corn with cowpea and bean: Biomass yield and silage quality. *African Journal of Biotechnology*, 7:4100-4104.

Ghanbari, A., Dahmardeh, M., Siahsar, B. A., and Ramroudi, M. (2010). Effect of maize (*Zea mays* L.)-cowpea (*Vigna unguiculata* L.) intercropping on light distribution, soil temperature and soil moisture in arid environment. *Journal of Food, Agriculture and Environment*, 8(1):102-108.

Ghosh, P. K. (2004). Growth, yield, competition and economics of groundnut/cereal fodder intercropping systems in the semi-arid tropics of India. *Field Crops Research*, 88: 227-237.

Gitari, H. I., Nyawade, S., Kamau, S., Karanja, N. N., Gachene, C. K. K., Raza, M. A., Maitra, S., and Schulte-Geldermann, E. (2020). Revisiting intercropping indices with respect to potato-legume intercropping systems. *Field Crops Research*, 258:1-12.

Glaze-Corcoron, S., Hashemi, M., Sadeghpour, A., Jahanzad, E., Keshavarz Afshar, R., Liu, X., and Herbert, S. J. (2020). Understanding intercropping to improve agricultural resiliency and environmental sustainability. *Advances in Agronomy*, 162:199-256.

Gong, W. Z., Jiang, C. D., Wu, Y. S., Chen, H. H., Liu, W. Y., and Yang, W. Y. (2015). Tolerance vs. avoidance: two strategies of soybean (*Glycine max*) seedlings in response to shade in intercropping. *Photosynthetica*, 53(2):259-268.

Gonkhamdee, S. (2010). *Analysis of interactions between rubber tree (Hevea brasiliensis Mull. Arg.) and inter-crop roots in young plantations of NE Thailand*. Ph.D Thesis, Université d'Avignon, Romania.

Guo, Z. M., Zhang, Y. Q., Deegen, P., and Uibrig, H. (2006). Economic analyses of rubber and tea plantations and rubber-tea intercropping in Hainan, China. *Agroforestry Systems*, 66(2):117-127.

Hamma, I. L., Yusuf, S. M., and Idris, U. D. (2015). Evaluation of maize (*Zea mays* L.) and okra (*Abelmoschus esculentus* L. Moench) intercropping system at Samaru, Zaria. *Journal of Advanced Research*, 2:16-22.

Hatfield, J. L. (2014). Radiation use efficiency: Evaluation of cropping and management systems. *Agronomy Journal*, 106(5):1820-1827.

Hauggaard-Nielsen, H., Gooding, M., Ambus,P., Corre-Hellou, G., Crozat, Y., Dahlmann, C., Dibet, A., Fragstein, P., Pristeri, A., Monti, M., and Jensen, E. S. (2009). Pea-barley intercropping for efficient symbiotic N -fixation, soil N acquisition and use of other nutrients in European organic cropping systems. *Field Crops Research*, 113:64-71.

Hiebsch, C. K., and McCollum, R. E. (1987). Area-×-Time Equivalency Ratio: A method for evaluating the productivity of intercrops. *Agronomy Journal*, 79:15-22.

Hirpa, T. (2014). Response of maize crop to spatial arrangement and staggered inter seeding of haricot bean. *International Journal of Environment*, 3:126-138.

Hougni, D. G. J. M., Chambon, B., Penot, E., and Promkhambut, A. (2018). The household economics of rubber intercropping during the immature period in Northeast Thailand. *Journal of Sustainable Forestry*, 37:787-803.

Huang, I. Y., James, K., Thamthanakoon, N., Pinitjitsamut, P., Rattanamanee, N., Pinitjitsamut, M., Yamklin, S., and Lowenberg-DeBoer, J. (2022). Economic outcomes of rubber-based agroforestry systems: a systematic review and narrative synthesis. *Agroforestry Systems*, 1-20.

Huehn, M. (1993). Harvest index versus grain-straw ratio. Theoretical comments and experimental results on the comparison of variation. *Euphytica*, 68(1-2):27-32.

Hu, F., Gan, Y., Chai, Q., Feng, F., Zhao, C., Yu, A., Mu, Y., and Zhang, Y. (2016). Boosting system productivity through the improved coordination of interspecific competition in maize-pea strip intercropping. *Field Crop Research*, 198:50–60.

Hugar, H. Y., and Palled, Y. B. (2008). Effect of intercropped vegetables on maize and associated weeds in maize-vegetable intercropping systems. *Karnataka Journal of Agricultural Sciences*, 21:159–161.

Hussain, I., Jatoi, S. A., Sayal, O., and Baloch, M. S. (2002). Green fodder yield and land equivalent ratio of sorghum-legume association. *Pakistan Journal of Biological Science*, 3:175-176.

Ijoyah, M. O. (2010). Effect of time of introducing maize on yield of white guinea yam (*Dioscoreae rotundata* P.) minisetts in Makurdi, Nigeria. *Agriculture and Biology Journal of North America*, 1:482-486.

Ijoyah, M. O., Adagba, E. O., and Iorlamen, T. (2012). Productivity of okra-maize intercropping system as influenced by varying maize plant densities in Makurdi, Nigeria. *International Journal of Current Research*, 4(4):059-063.

Ijoyah, M. O., and Dzer, D. M. (2012). Yield performance of okra (*Abelmoschus esculentus* L. Moench) and maize (*Zea mays* L.) as affected by time of planting maize in Makurdi, Nigeria. *International Scholarly Research Network*, 2012:1-7.

Ijoyah, M. O., and Jimba, J. (2012). Evaluation of yield and yield components of maize (*Zea mays* L.) and okra (*Abelmoschus esculentus* L. Moench) intercropping system at Makurdi, Nigeria. *Journal of Biodiversity and Environmental Sci*ence, 2(2):38-44.

Ijoyah, M. O., Usman, A. U., and Odiaka, N. I. (2015). Yield response of cassava-okra intercrop as influenced by population densities and time of introducing okra in Makurdi, Nigeria. *World Scientific News*, 18:133-154.

Ion, V., Dicu, G., Dumbravă, M., Temocico, G., Alecu, I. N., Băşa, A. G., and State, D. (2015). Harvest index at maize in different growing conditions. *Romanian Biotechnological Letters*, 20(6):10951-10960.

Iqbal, A., Amanullah, A., and Iqbal, M. (2015). Impact of potassium rates and their application time on dry matter partitioning, biomass and harvest index of maize (*Zea mays*) with and without cattle dung application. *Emirates Journal of Food and Agriculture*, 27(5):447-453.

Iqbal, M. A., Bethune, B. J., Asif Rana, N. A., Zubair, A., Haroon, Z. K., and Bilal, A. (2017). Agro botanical response of forage sorghum-soybean intercropping systems under a typical spatio- temporal pattern. *Pakistan Journal of Botany*, 49:987-994.

Iqbal, M. A., Iqbal, A., Ayub, M., and Akhtar, J. (2016). Comparative study on temporal and spatial complementarity and profitability of forage sorghum-soybean intercropping systems. *Custos Agronegocio Online*, 12:2-18.

Jahanzad, E., Sadeghpour, A., Hosseini, MB., Barker, AV., Hashemi, M., and Zandvakili, O. R. (2014). Silage yield and nutritive value of millet–soybean intercrops as influenced by nitrogen application. *Agronomy Journal*, 106:1993-2000.

Jat, R., and Ahlawat, I. (2010). Effect of organic manure and sulphur fertilization in pigeonpea + groundnut intercropping system. *Indian Journal of Agronomy*, 55:276-281.

Jiao, N. Y., Zhao, C., Ning, T. Y., Hou, L. T., Fu, G. Z., Li, Z. J., and Chen, M. C. (2008). Effect of maize peanut intercropping on economic yield and light response of photosynthesis. *Chinese Journal of Plant Ecology*, 19:981-985.

Juraimi, A. S. (2018). Agriculture: Addressing food security in Malaysia. Retrieved from: https://www.theedgemarkets.com/ article/agriculture-addressing-food-security-malaysia/ (Accessed June 23, 2022).

Juskiw, P. E., Helm, J. H., and Salmon, D. F. (2000). Forage yield and quality for monocrops and mixtures of small grain cereals. *Crop Science*, 40:138–147.

Kaur, S., Dhanda, S., Yadav, A., Sagwal, P., Yadav, D. B., and Chauhan, B. S. (2022). Current status of herbicide-resistant weeds and their management in the rice-wheat cropping system of South Asia. *Advances in Agronomy*, 17:307-354.

Kawano, M. (2019). Changing resource-based manufacturing industry: The case of the rubber industry in Malaysia and Thailand. *Emerging-Economy State and International Policy Studies*. Singapore: Springer.

Kermah, M., Franke, A. C., Adjei-Nsiah, S., Ahiabor, B. D., Abaidoo, R. C., and Giller, K. E. (2017). Maize-grain legume intercropping for enhanced resource use efficiency and crop productivity in the Guinea savanna of northern Ghana. *Field Crops Research*, 213:38-50.

Khalequzzaman, K. M., Siddquie, M. N. A., Khatun, M. J., Hussain, M. A., and Ahmed, R. N. (2014). Studies on Maize-Okra-T.Aman cropping pattern at Sherpur, Bogra, Bangladesh. *International Journal of Experimental Agriculture*, 4(2):12-16.

Khan, M., Muhammad, N., Iqbal, J., Aktar, N., and Hassan, M. (2005). Studies on mixed cropping of cowpea and mungbean in sorghum and millet for green fodder yield under rainfed conditions of Kohet division. *Indus Journal of Plant Sciences*, 4:521-523.

Khan, Z., Rahman, M. H. U., Haider, G., Amir, R., Ikram, R. M., Ahmad, S., Schofield, H. K., Riaz, B., Iqbal, R., Fahad, S., Datta, R., Baazem, A., Sabagh, A. E., and Danish, S. (2021). Chemical and biological enhancement effects of biochar on wheat growth and yield under arid field conditions. *Sustainability*, 13(11):1-18.

Khanal, U., Stott, K. J., Armstrong, R., Nuttall, J. G., Henry, F., Christy, B. P., Mitchell, M., Riffkin, P. A., Wallace, A. J., McCaskill, M., Thayalakumaran, T., and O'Leary, G. J. (2021). Intercropping—evaluating the advantages to broadacre systems. *Agriculture*, 11(5):453-473.

Kheroar, S., and Patra, B. C. (2013). Advantages of maize-legume intercropping systems. *Journal of Agricultural Science and Technology*, 3(3):733-744.

Kimura, E., Fransen, S. C., Collins, H. P., Stanton, B. J., Himes, A., Smith, J., and Johnston, W. J. (2018). Effect of intercropping hybrid poplar and switch grass on biomass yield, forage quality, and land use efficiency for bioenergy production. *Biomass and Bioenergy*, 111:31-38.

Koskey, G., Leoni, F., Carlesi, S., Avio, L., and Bàrberi, P. (2022). Exploiting plant functional diversity in durum wheat–lentil relay intercropping to stabilize crop yields under contrasting climatic conditions. *Agronomy*, 12(1):210-225.

Kozicka, M., Jones, S. K., Gotor, E., and Enahoro, D. (2022). Cross-scale trade-off analysis for sustainable development: linking future demand for animal source foods and ecosystem services provision to the SDGs. *Sustainability Science*, 17(1):209-220.

Kroeksakul, P., Naipinit, A., and Sakolnakorn, T.P.N. (2011). The economic and social effects of farmers growing para rubber in northeast Thailand: A case study of Sapsomboon village, Dun Sad sub-district, Kranoun district, Khon Kaen province. *Journal of Business Case Studies*, 7(1):1-6.

Kshash, B. H., and Oda, H. K. (2021). Economics of okra production. *EasyChair*, 6131:1-12.

Kumar, A., Kumar,P. and Nadendla, R. (2013). A review on: *Abelmoschus esculentus* (Okra). *International Research Journal of Pharmaceutical and Applied Sciences*, 3:129-132.

Kumar, S., Kumar, S., and Mohapatra, T. (2021). Interaction between macro-and micro-nutrients in plants. *Frontiers in Plant Science*, 12:1-9.

Kumi, F., Adade, R., Darko, R. O., Ekumah, B., and Osei, G. (2021). Estimating okra leaf area index using unmanned aerial vehicle imagery. *Agricultural Engineering International: CIGR Journal*, 23(2):288-296.

Kushwaha, S., Singh, K., and Kushwaha, R. (2018). Okra: A study on cost and profitability analysis in Deoria District of Uttar Pradesh. *Journal of Pharmacognosy and Phytochemistry*, 7(5):153-156.

Langat, M. C., Okiror, M. A., Ouma, J. P., and Gesimba, R. M. (2006). The effect of intercropping groundnut (*Arachis hypogea* L.) with sorghum (*Sorghum bicolor* L.) on yield and cash income. *Agricultura Tropica at Subtropica*, 39:88-96.

Langenberger, G., Cadisch, G., Martin, K., Min, S., and Waibel, H. (2016). Rubber intercropping: A viable concept for the 21st century? *Agroforestry Systems*, 91(3):577–596.

Langert, M. C., Okiror, M. A., Onma, J. P., and Gesimba, R. M. (2006). The effect of intercropping groundnut (*Arachis hypogea* L.) with sorghum (*Sorghum bicolor* L. Moench) on yield and cash income. *Tropical Agriculture*, 39:87-91.

Leger, E. A., Agneray, A. C., Baughman, O. W., Brummer, E. C., Erickson, T. E., Hufford, K. M., and Kettenring, K. M. (2021). Integrating evolutionary potential and ecological function into agricultural seed production to meet demands for the decade of restoration. *Restoration Ecology*, e13543:1-11.

Leshem, A., Aenis, T., Grötz, P., Darnhofer, I., and Grötzer, M. (2010). *Can intercropping innovations bring ecological and economic goals together? The case of Nabanhe Nature Reserve, China.* Paper presented at the 9th European IFSA Symposium, Vienna, Austria.

Li, H., Ma, Y., Aide, T. M., and Liu, W. (2008). Past, present and future land use in Xishuangbanna, China and the implications for carbon dynamics. *Forest Ecology and Management*, 255(1):16-24.

Li, L., Sun, J., Zhang, F., Li, X., Yang, S., and Rengel, Z. (2001). Wheat-maize or wheat-soybean strip intercropping: Yield advantage and interspecific interactions on nutrients. *Field Crop Research*., 71:123–137.

Li, Q. Z., Sun, J. H., Wei, X. J., Christie, P., Zhang, F. S., and Li, L. (2011). Overyielding and interspecific interactions mediated by nitrogen fertilization in strip intercropping of maize with faba bean, wheat and barley. *Plant and Soil*, 339(1–2):147–161.

Li, X., Mu, Y., Cheng, Y., Liu, X., and Nian, H. (2013). Effects of intercropping sugarcane and soybean on growth, rhizosphere soil microbes, nitrogen and phosphorus availability. *Acta Physiologiae Plantarum*, 35(4):1113–1119.

Lithourgidis, A. S., Vlachostergios, D. N., Dordas, C. A., and Damalas, C. A. (2011). Dry matter yield, nitrogen content, and competition in pea–cereal intercropping systems. *European Journal of Agronomy*, 34: 287-294.

Lithourgidis, A. S., Vasilakoglou, I. B., Dhima, K. V., Dordas, C. A., and Yiakoulaki, M. D. (2006). Forage yield and quality of common vetch mixtures with oat and triticale in two seeding ratios. *Field Crop Research*, 99(2):106–113.

Liu, T., Song, F., Liu, S., and Zhu, X. (2012). Light interception and radiation use efficiency response to narrow-wide row planting patterns in maize. *Australian Journal of Crop Science*, 6(3):506-513.

Liu, X., Rahman, T., Yang, F., Song, C., Yong, T., Liu, J., Zhang, C., and Yang, W. (2017). PAR interception and utilization in different maize and soybean intercropping patterns. *Plos One*, 12(1): e0169218.

Ma, H., Zhou, J., Ge, J., Nie, J., Zhao, J., Xue, Z., Hu, Y., Yang, Y., Peixoto, L., Zang, H., and Zeng, Z. (2022). Intercropping improves soil ecosystem multifunctionality through enhanced available nutrients but depends on regional factors. *Plant and Soil*, 1-14.

Madu, F.O. and Nwosu, S.K. (2001). *Effect of fertilizer and time of interplanting maize on the performance of yam-maize intercrop.* Paper presented at the Second Annual Farming Systems Research and Extension Workshop, Umudike, Nigeria.

Maitra, S. (2019). Potential of intercropping system in sustaining crop productivity. *International Journal of Agriculture, Environment and Biotechnology*, 12:39-45.

Maitra, S., Hossain, A., Brestic, M., Skalicky, M., Ondrisik, P., Gitari, H., Brahmachari, K., Shankar, T., Bhadra, P., Palai, J. B., Jena, J., Bhattacharya, U., Duvvada, S. K., Lalichetti, S., and Sairam, M. (2021). Intercropping—A low input agricultural strategy for food and environmental security. *Agronomy*, 11(2):343.

Makinde, A. I., Oyekale, K. O., and Daramola, D. S. (2022). Growth and yield of okra (*Abelmoschus esculentus* L. Moench) as influenced by fertilizer application under different cropping systems. *Agricultural Socio-Economics Journal*, 22(1):1-8.

Maluleke, M. H., Bediako, A. A., and Ayisi, K. K. (2005). Influence of maize-lablab intercropping on Lepidopterous stemborer infestation in maize. *Journal of Economic Entomology*, 98:384-388.

Mandal, K. G., and Sinha, A. C. (2004). Nutrient management effects on light interception, photosynthesis, growth, dry-matter production and yield of Indian mustard (*Brassica juncea*). *Journal of Agronomy and Crop Science*, 190(2):119-129.

Manga, A. A., Bala, M. G., and Ashafa, L. W. (2003). Evaluation of maize (*Zea mays* L.) and grain amaranth (*Amaranthus cruentus* L.) intercrop. *Nigerian Journal of Horticulture Sciences,* 8:7-10.

Maniriho, A., and Bizoza, A. (2013). Financial benefit-cost analysis of agricultural production in Musanze District (Rwanda). *Academic Arena*, 5(12):30-9.

Mao, L., Zhang, L., Zhao, X., Liu, S., van der Werf, W., Zhang, S., Spiertz, H., and Li, Z. (2014). Crop growth, light utilization and yield of relay intercropped cotton as affected by plant density and a plant growth regulator. *Field Crop Research*, 155:67–76.

MARDI. (2005). Manual penanaman jangung manis, *Malaysian Agricultural Research and Development Institute (pp. 17-19)*. Malaysia, MARDI.

Mariscal, M. J., Orgaz, F., and Villalobos, F. J. (2000). Modelling and measurement of radiation interception by olive canopies. *Agricultural and Forest Meteorology*, 100(2-3): 183-197.

Masvaya, E. N., Nyamangara, J., Descheemaeker, K., and Giller, K. E. (2017). Is maize-cowpea intercropping a viable option for smallholder farms in the risky environments of semi-arid southern Africa? *Field Crops Research*, 209:73-87.

McGilchrist, C. A., and Trenbath, B. R. (1971). A revised analysis of plant competition experiments. *Biometrics*, 1:659-671.

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

Michael U (2006). Keynote address at the Presidential Initiative on Rubber Production and Utilization, Rubber Research Institute, Nigeria.

Midya, A., K. Bhattacharjee, K., Ghose, S. S., and Banik, P. (2005). Differed seeding of blackgram (*Phaseolus mungo* L.) in rice (*Oriza sativa* L.) field on yield advantages and smothering of weeds. *Journal of Agronomy and Crop Science*, 191:195-201.

Mobasser, H. R., Vazirimehr, M. R., and Rigi, K. (2014). Effect of intercropping on resources use, weed management and forage quality. *International Journal of Plant, Animal and Environmental Sciences*, 4(2):706-713.

Mohamadu, B. J. (2003). *Modelling and simulation of radiation interception and biomass production in an immature-rubber, banana and pineapple intercropping system*. Ph.D Thesis, Universiti Putra Malaysia, Malaysia.

Mohamadu, B. J., Wan Sulaiman, W. H., Jamal, T., Mohd Fauzi, R., Rajan, A., Christopher, T. B. S., and Osumanu, H. A. (2009). A simulation model estimates of the intercropping advantage of an immature-rubber, banana and pineapple system. *American Journal of Agricultural and Biological Science*, 4(3):249-254.

Monteith, J. L. (1972). Solar radiation and productivity in tropical ecosystem. *Journal of Applied Ecology*, 9:747-766.

Monteith, J. L., and Moss, C. J. (1977). Climate and the efficiency of crop production in Britain. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 281(980):277–294.

Morales-Ruiz, A., Loeza-Corte, J. M., Díaz-López, E., Morales-Rosales, E. J., Franco-Mora, O., Mariezcurrena-Berasaín, M. D., and Estrada-Campuzano, G. (2016). Efficiency on the use of radiation and corn yield under three densities of sowing. *International Journal of Agronomy*, 1:1-5.

Morgado, L. B., and Willey, R. W. (2008). Optimum plant population for maize-bean intercropping system in the Brazilian semi-arid region. *Scientia Agricola*, 65:474-480.

Mousavi, S. R., and Eskandari, H. (2011). A general overview on intercropping and its advantages in sustainable agriculture. *Journal of Applied Environmental and Biological Sciences*, 1(11):482-486.

MRB (2019). Natural rubber statistics 2019. Retrieved from: http://www.lgm.gov.my/nrstat/Statistics%20Website%202020%20(Jan-Jun).pdf (Accessed June 03, 2020).

MRB (2022). Natural rubber market review. Retrieved from: https://www.lgm.gov.my/webv2/activitiesServices/publication/(publication:mrb digest)/ (Accessed June 21, 2022).

MRC (2022). Malaysian rubber production, consumption and trade. Retrieved from: https://www.myrubbercouncil.com/industry /malaysia_production.php/ (Accessed June 21, 2022).

Mucheru-Muna, M., Mugendi, D. N., Pypers, P., Mugwe, J., Vanlauwe, B., Merckx, R., and Kung'u, J. B. (2011). Increasing productivity through maize–legume intercropping in Central Kenya. *Proceedings of the Innovations as Key to the Green Revolution in Africa (pp. 843-858)*. Dordrecht: Springer.

Muoneke, C. O., and Asiegbu, J. E. (1997). Effect of okra planting date and spatial arrangement in intercrop with maize on the growth and yield of component species. *Journal of Agronomy and Crop Science*, 179:201-207.

Muoneke, C. O., and Mbah, E. U. (2007). Productivity of cassava/okra intercropping systems as influenced by okra planting density. *African Journal of Agricultural Research*, 2:223-231.

Muoneke, C. O., and Ndukwe, O. O. (2008). Effect of plant population and spatial arrangement on the productivity of okra-amaranthus intercropping system. *Agro-Science*, 7:15-21.

Muoneke, C. O., Asiegbu, J. E., and Udeogalanya, A. C. C. (1997). Effect of relative sowing time on the growth and yield of the component crops in okra-maize and okra-cowpea intercropping systems. *Journal of Agronomy and Crop Science*, 179:179-185.

Nur Arina, I. (2019). *Growth performance, yield and quality of sweet potato (Ipomoea batatas L. Lam) in response to different cropping systems*. M. Sc. Thesis, Universiti Putra Malaysia, Malaysia.

Nur Arina, I., Martini, M. Y., Surdiana, S., Mohd Fauzi, R., and Zulkefly, S. (2021). Radiation dynamics on crop productivity in different cropping systems. *International Journal of Agronomy*, 2021:1-8.

Nurmi-Rohayu, A. H., Rasyidah, M. R., Zarawi, A. G., Mohd-Nasaruddin, M. A., Noorliana, M. Z., Nor-Afiqah, M., and Aizat-Shamin, N. (2015). MRB clone recommendations. *Buletin Sains dan Teknologi, LGM*, 1(13):10-12.

Nwokoro, C. C., Kreye, C., Necpalova, M., Adeyemi, O., Barthel, M., Pypers, P., Hauser, S., and Six, J. (2022). Cassava-maize intercropping systems in southern Nigeria: Radiation use efficiency, soil moisture dynamics, and yields of component crops. *Field Crops Research*, 283:1-16.

Odedina, J. N., Fabunmi, T. O., Adigbo, S. O., Odedina, S. A., and Kolawole, R. O. (2014). Evaluation of cowpea varieties (*Vigna unguiculata* L. Walp) for intercropping with okra (*Abelmoschus esculenta* L. Moench). *American Journal of Research Communication*, 2:91-108.

Ofosu-Anim, J., and Limbani, N. V. (2007). Effect of intercropping on the growth and yield of cucumber (*Cucumis sativus* L.) and okra (*Abelmoschus esculentus* L. Moench). *International Journal Agriculture and Biology*, 9(4):594-597.

Oyewole, C. I. (2010). Maize-okra intercrop as affected by cropping pattern in Kogi State, Nigeria. *Continental Journal Agronomy*, 4:1-9.

Oyewole, C. I., Amhakhian, S. O., and Otitolaiye, J. O. (2012). Economics return on maize (*Zea mays* L.) – Okra (*Abelmoschus esculentus* (L.) Moench) enterprise as affected by component crop arrangement in mixture. *International Journal of Agricultural Economics, Management and Development*, 1:136-145.

Partelli, F. L., Araújo, A. V., Vieira, H. D., Dias, J. R. M., Menezes, L. F. T. D., and Ramalho, J. C. (2014). Microclimate and development of 'Conilon' coffee intercropped with rubber trees. *Pesquisa Agropecuaria Brasileira*, 49:872-881.

Pathiratna, L. S. S., and Edirisinghe, J. C. (2004). Agronomic and economic viability of rubber (*Hevea brasiliensis* Muell.Arg.)-cinnamon (*Cinnamomun verum*) intercropping systems involving wider inter-row spacing in rubber plantations. *Journal of the Rubber Research Institute of Sri Lanka*, 86:46-57.

Pronk, A. A., Goudriaan, J., Stilma, E., and Challa, H. (2003). A simple method to estimate radiation interception by nursery stock conifers: a case study of eastern white cedar. *Wageningen Journal of Life Sciences*, 51:279–295.

Radford, P. J. (1967). Growth analysis formulae-their use and abuse 1. *Crop Science*, 7(3):171-175.

Rahman, T., Liu, X., Hussain, S., Ahmed, S., Chen, G., Yang, F., Chen, L., Du, J., Liu, W., and Yang, W. (2017). Water use efficiency and evapotranspiration in maize-soybean relay strip intercrop systems as affected by planting geometries. *Plos One*, 12:e0178332.

Rajasekharan, P., and Veeraputhran, S. (2002). Adoption of intercropping in rubber small holdings in Kerala, India: a tobit analysis. *Agroforestry Systems*, 56(1):1-11.

Rami, V., Jadav, S., and Macwan, J. (2018). Economic analysis of cost and return of okra in Middle Gujarat. *International Journal of Agriculture Sciences*, 10(20):7348-7351.

Rathore, B. M. (2015). Growth and fodder yields of sorghum and cowpea in sole and intercropping systems. *BIOINFOLET – A Quarterly Journal of Life Sciences*, 12:777-779.

Raza, M. A., Feng, L. Y., van der Werf, W., Cai, G. R., Khalid, M. H., Iqbal, N., Hassan, M. J., Meraj, T. A., Naeem, M., Khan, I., Rehman, S., Ansar, M., Ahmed, M., Yang, F., and Yang, W. (2019). Narrow-wide-row planting pattern increases the radiation use efficiency and seed yield of intercrop species in relay-intercropping system. *Food Energy Security,* 8(3):1-12.

Ren, Y., Zhang, L., Yan, M., Zhang, Y., Chen, Y., Palta, J. A., and Zhang, S. (2021). Effect of sowing proportion on above-and below-ground competition in maize–soybean intercrops. *Scientific Reports*, 11(1):1-12.

Rezig, M., Sahli, A., Hachicha, M., Jeddi, F. B., and Harbaoui, Y. (2013). Potato (*Solanum tuberosum* L.) and bean (*Phaseolus vulgaris* L.) in sole intercropping: Effects on light interception and radiation use efficiency. *Journal of Agricultural*, 5(9):65-77.

Robichaud, C. D., and Rooney, R. C. (2022). Differences in above-ground resource acquisition and niche overlap between a model invader (*Phragmites australis*) and resident plant species: measuring the role of fitness and niche differences in the field. *Biological Invasions*, 24(3):649-682.

Rodrigo, V. H. L., Stirling, C. M., Silva, T. U. K., and Pathirana, P. D. (2005). The growth and yield of rubber at maturity is improved by intercropping with banana during the early stage of rubber cultivation. *Field Crops Research*, 91:23–33.

Rosa, F. H., Edwin, H., Lianqing, Z., Francisco, E., Jo-Anne, L. J. E. D., Christopher, C. M., Casiana, M. V. C., and Karen, A. G. (2017). Cropping system diversification for food production in Mindanao rubber plantations: a rice cultivar mixture and rice intercropped with mungbean. *PeerJ*., 5:1-20.

Rouf Shah, T., Prasad, K., and Kumar, P. (2016). Maize—A potential source of human nutrition and health: A review. *Cogent Food and Agriculture*, 2:1-9.

Sadeghpour, A., Jahanzad, E., Esmaeili, A., Hosseini, M. B., and Hashemi, M. (2013). Forage yield, quality and economic benefit of intercropped barley and annual medic in semi-arid conditions: Additive series. *Field Crops Research*, 148:43-48.

Sadeghpour, A., Hashemi, M., and Herbert, S. J. (2014). A simple vigor test for adjusting switchgrass seeding rate in marginal and fertile soils. *Grassland Science*, 60(4):252–255.

Salako, A. A., Olubanjo, O. O., and Okeowo, T. A. (2013). Comparative cost-returns structures of irrigated and rainfed arable crops production in Ogun-Oshun River Basin Development Authority Project Areas. *International Journal of Food and Agricultural Research*, 10(1-2):34-42.

Saputra, H., and Mutaqin, Z. (2022). Morphological responses of edamame soybean and sweet corn planted in intercropping with combinations of plant populations on three varieties of sweet corn. *Earth and Environmental Science*, 1012(1):1-10.

Sarker, U. K., Dey, S., Kundu, S., and Awal, M. A. (2013). On-farm study on intercropping of hybrid maize with short duration vegetables. *Journal of the Bangladesh Agricultural University*, 11(1):1-4.

Semerci, A., Parlakay, O., and Çelik, A. D. (2014). Gross margin analysis in dairy cattle: a case study of Hatay Province, Turkey. *Custos Agronegocio*, 10:154-170.

Seran, T. H., and Brintha, I. (2010). Review on maize-based intercropping. *Journal of Agronomy*, 9(3):135-145.

Seran, T. H., and Jeyakumaran, J. (2009). Effect of planting geometry on yield of capsicum (*Capsicum annum* L.) intercropping with vegetable cowpea (*Vigna unguiculata* L.). *Journal of Science*, 6:11–19.

Setu, H., and Mitiku, T. (2018). Okra (*Abelmoschus esculentus* L.) – maize (*Zea mays* L.) intercropping as affected by cropping pattern at Assosa, Benishangul Gumuz Region, Western Ethiopia. *Academia Journal of Agricultural Research*, 6(4):93-99.

Sharib, S., and Halog, A. (2017). Enhancing value chains by applying industrial symbiosis concept to the Rubber City in Kedah, *Malaysia. Journal of Cleaner Production*, 141:1095–1108.

Siju, T., George, K. T., and Lakshmanan, R. (2012). Changing dimensions of intercropping in the immature phase of natural rubber cultivation: A case study of pineapple intercropping in Central Kerala. *Rubber Science*, 25(2):164-172.

Singh, P., Chauhan, V., Tiwari, B. K., Chauhan, S. S., Simon, S., Bilal, S., and Abidi, A. B. (2014). An overview on okra (*Abelmoschus esculentus*) and it's importance as a nutritive vegetable in the world. *International Journal of Pharmacy and Biological Sciences*, 4(2): 227-233.

Singh, R. S., Gohain, T., Meti, S., Choudhuri, D., Singh, R. P., Nazeer, M. A., and Jacob, J. (2019). Feasibility of rubber + tea intercropping during immature phase of rubber. *International Journal of Current Microbiology and Applied Sciences*, 8:1873–1879.

Snoeck, D., Lacote, R., Keli, J., Doumbia, A., Chapuset, T., Jagoret, P., and Gohet, E. (2013). Association of hevea and other tree crops can be more profitable than hevea monocrop during first 12 years. *Industrial Crops and Products*, 43:578–586.

Su, B.Y., Cui, L., Yong, T. W., Yang, W. Y., Song, C., and Song, Y. X. (2014). Growth and photosynthetic responses of soybean seedlings to maize shading in relay intercropping system in Southwest China. *Photosynthetica*, 52(3):332–340.

Suarez, J. C., Anzola, J. A., Contreras, A. T., Salas, D. L., Vanegas, J. I., Urban, M. O., Beebe, S. E., and Rao, I. M. (2022). Agronomic performance evaluation of intercropping two common bean breeding lines with a maize variety under two types of fertilizer applications in the Colombian Amazon Region. *Agronomy*, 12(2):307-324.

Sun, T., Zhao, C., Feng, X., Yin, W., Gou, Z., Lal, R., Deng, A., Chai, Q., Song, Z., and Zhang, W. (2021). Maize-based intercropping systems achieve higher productivity and profitability with lesser environmental footprint in a water-scarce region of northwest China. *Food and Energy Security*, 10(1):1-14.

Surve, V. H., Arvadia, M. K., and Tandel, B. B. (2012). Effect of row ratio in cereal-legume fodder under intercropping systems on biomass production and economics. *International Journal of Agriculture: Research and Review*, 2(1):34-35.

Szeicz, G. (1974). Solar radiation in canopies. *Journal of Applied Ecology*, 11:1117-1156.

Tahir, M., Malik, M. A., Tanveer, A., and Ahmad, R. (2003). Competition functions of different canola-based intercropping systems. *Asian Journal of Plant Sciences*, 2:9-11.

Taskiner, T., and Bilgen, B. (2021). Optimization models for harvest and production planning in agri-food supply chain: A systematic review. *Logistics*, 5(3):52-79.

Teresa, K. S. S. (2018). Rubber to surpass palm oil contribution to economy. Retrieved from: https://www.thestar.com.my/ business/ businessnews/2018/09/19/rubber-to-surpass-palm-oil contribution-to-economy/ (Accessed September 19, 2018).

Tesfaye, K., Walker, S., and Tsubo, M. (2006). Radiation interception and radiation use efficiency of three grain legumes under water deficit conditions in a semi-arid environment. *European Journal of Agronomy*, 25:60–70.

Tetteh, E. N., Abunyewa, A. A., Tuffour, H. O., Berchie, J. N., Acheampong, P. P., Twum-Ampofo, K., Dawoe, E., Logah, V., Agbenyega, O., Ennin, S. A., Nunoo, I., Melenya, C., Danquah, E. O., Barnes, V. R., and Partey, S. T. (2019). Rubber and plantain intercropping: Effects of different planting densities on soil characteristics. *Plos One*, 14(1): e0209260.

Tetteh, E. N., Owusu Danquah, E., Abunyewa, A. A., Melenya Ocansey, C., Boakye, E. A., Tuffour, H. O., Logah, V., Twum-Ampofo, K., Dzomeku, B. M., Yeboah, S., and Barnes, V. R. (2021). Plantain-tree rubber intercropping systems improved productivity in the Tropical Humid Zone of Ghana, West Africa. *International Journal of Agronomy*, 2021:1-16.

Thapa, N. (2021). Forms of exclusion in the innovation process–an analysis of access to formal organizations by small plantation growers in India. *Innovation and Development*, 1-19.

Tsubo, M., and Walker, S. (2002). A model of radiation interception and use by a maize-bean intercrop canopy. *Agricultural of Forest Meteorologi*, 110:203- 215.

Tsubo, M., Ogindo, H. O., and Walker, S. (2004). Yield evaluation of maize-bean intercropping in a semi-arid region of South Africa. *African Crop Science Journal*, 12(4):351-358.

Undie, U. L., Uwah, D. F., and Attoe, E. E. (2012). Effect of intercropping and crop arrangement on yield and productivity of late season maize-soybean mixtures in the humid environment of South Southern Nigeria. *Journal of Agricultural Science*, 4(4):37-50.

Usman, S. D. (2001). Seed production and quality of okra as affected by sowing time. *Seed Research*, 29(1):47-51.

Vichot, J., and Somyot, T. (2014). Resilience of rubber-based intercropping system in Southern Thailand. *Advanced Materials Research*, 844:24-29.

Viswanathan, P. K., and Shivakoti, G. P. (2008). Adoption of rubber integrated farm livelihood systems: Contrasting empirical evidence from the Indian context. *Journal of Forest Research*, 13(1):1–14.

Wang, G., Bei, S., Li, J., Bao, X., Zhang, J., Schultz, P. A., Li, L., Zhang, F., Bever, J. D., and Zhang, J. (2021). Soil microbial legacy drives crop diversity advantage: Linking ecological plant–soil feedback with agricultural intercropping. *Journal of Applied Ecology*, 58(3):496-506.

Wang, Z. G., Jin, X., Bao, X. G., Li, X. F., Zhao, J. H., Sun, J. H., Christie, P., and Long, L. (2014). Intercropping enhances productivity and maintains the most soil fertility properties relative to sole cropping. *Plos One*, 9(12): e113984.

Wasaya, A., Ahmad, R., Hassan, F. U., Ansar, M., Manaf, A., and Sher, A. (2013). Enhancing crop productivity through wheat (*Triticum aestivum* L.)- fenugreek intercropping system. *Journal of Animal and Plant Sciences*, 23(1):210-215.

Willey, R. W. (1985). Evaluation and presentation of intercropping advantages. *Experimental Agriculture*, 21:119-133.

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

Wu, Y., Gong, W., Yang, F., Wang, X., Yong, T., and Yang, W. (2016). Responses to shade and subsequent recovery of soya bean in maize-soya bean relay strip intercropping. *Plant Production Science*, 19(2):206–214.

Xia, W., Fengzhi, W., Xingang, Z., Xuepeng, F., Yue, T., Weihui, X., Kai, P., and Shouwei, L. (2016). Effects of intercropping with potato onion on the growth of tomato and Rhizosphere alkaline Phosphatase genes diversity. *Frontier in Plant Science*, 7(846):1-13.

Xiolei, S., and Zhifeng, W. (2002). *The optimal leaf area index for cucumber photosynthesis and production in plastic greenhouse*. Paper presented at the XXVI International Horticultural Congress, Toronto, Canada.

Yahuza, I. (2011). Review of some methods of calculating intercrop efficiencies with particular reference to the estimates of intercrop benefits in wheat-faba bean system. *International Journal of Biosciences*, 1(5):18-30.

Yang, C., Fan, Z., and Chai, Q. (2018). Agronomic and economic benefits of pea-maize intercropping systems in relation to N fertilizer and maize density. *Agronomy*, 8(4):52.

Yang, F., Huang, S., Gao, R., Liu, W., Yong, T., Wang, X., Wang, X., and Yang, W. (2014). Growth of soybean seedlings in relay strip intercropping systems in relation to light quantity and red: far-red ratio. *Field Crop. Research*, 155:245–253.

Yang, F., Liao, D., Wu, X., Gao, R., Fan, Y., Raza, M. A., Wang, X., Yong, T., Liu, W., Liu, J., Du, J., Shu, K., and Yang, W. (2017). Effect of aboveground and belowground interactions on the intercrop yields in maize-soybean relay intercropping systems. *Field Crops Research*, 203:16–23.

Yavas, I., and Unay, A. (2016). Evaluation of physiological growth parameters of maize in maize-legume intercropping system. *The Journal of Animal and Plant Sciences*, 26(6): 1680-1687.

Yayeh, B., Fekremariam, A., and Oumer, B. (2014). Effect of plant spacing on the yield and yield component of field pea (Pisum Sativum L.) at Adet, Northwestern Ethiopia. *Agriculture, Forestry and Fisheries*, 3(5):368-373.

Yong, T., Chen, P., Du, Q., Yang, F., Wang, X., Liu, W., and Dong, Q. (2018). Optimized nitrogen application methods to improve nitrogen use efficiency and nodule nitrogen fixation in a maize-soybean relay intercropping system. *Journal of Integrative Agriculture*, 17(3):664–676.

York, L. M., Griffiths, M., and Maaz, T. M. (2022). Whole-plant phenotypic engineering: moving beyond ratios for multi-objective optimization of nutrient use efficiency. *Current Opinion in Biotechnology*, 75:2-7.

Yumiko, S., Raquel, P. O., Taiichiro, O., Takashi, M., and Tadashi, H. (2006). Effects of planting pattern on the interception of solar radiation by the canopy and the light extinction coefficient of the canopy in rice plants direct sown in a submerged paddy field. *Plant Production Science*, 9(3):334-342.

Yusuff, M. T. M., Ahmed, O. H., Yahaya, W. A. W., and Majid, N. M. A. (2007). Effect of organic and inorganic fertilizers on nitrogen and potassium uptake and yield of sweet corn grown on an acid soil. *American Journal of Agriculture and Biological Sciences*, 2: 118-122.

Zegada-Lizarazu, W., Parenti, A., and Monti, A. (2021). Intercropping grasses and legumes can contribute to the development of advanced biofuels. *Biomass and Bioenergy*, 149:1-9.

Zhang, L. Z., Werf, W. V. D., Bastiaans, L., Zhang, S., Li, B., and Spiertz, J. H. J. (2008). Light interception and utilization in relay intercrops of wheat and cotton. *Field Crops Research*, 107: 29–42.

Zhou, X., Yu, G., and Wu, F. (2011). Effects of intercropping cucumber with onion or garlic on soil enzyme activities, microbial communities and cucumber yield. *European Journal of Soil Biology*, 47:279–287.