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Crop-Tree Interactions and Nutritional Statues of Citrus under Agroforestry Cropping System

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Abstract: Solid and inter-planted citrus with four winter field crops were compared to assess the effect of agroforestry of some field crops with citrus trees which considered as an approach to establish biodiversity in fruit tree plantations. Four field crops i.e., lupin, wheat, canola and faba bean were inter-planted with seedless orange trees(4*4 m) or were planted as solid planting. The results for the trees on the solid and inter-planted crops apparently indicated a larger fruit yield from the solid plots. Statistically significant effects ($P<0.05$) were found for wheat grains, canola and faba bean seeds yields under agroforestry plantations. However, straw yields were not affected when inter- planted with citrus . Whilst inter-planted crops did not differ than the solid plantings the advantage of inter- planting these crops with citrus increase yields except lupin increase yields by 9-11 % compared with solid plantings of these crops. However, there were significant reduction of inter-planted citrus with field crops. Tissue analysis showed that, whilst there may be a small benefit of agroforestry to leaf content of NPK, there are no discernible differences in trace element concentrations. The data clearly indicate that nearly two folds of N concentration were found in citrus leaf compared with fruit only while P and K concentrations were similar either in leaf or fruit. N translocation from citrus Leaf to fruit was similar while P under inter-planting was greater than the solid planting, K was greater in solid planting than inter-planting. Micronutrient translocation from soil to citrus fruits followed the order Cu > Zn > Mn >Fe.

Key words: Inter-planting · Agroforestry · Citrus · Wheat · Canola · Lupin · Faba bean · Nutritional status

INTRODUCTION

Agroforestry is defined as a collective name for land use systems in which woody perennials (trees, shrubs, etc.) are grown in association with herbaceous plants (crops, pastures) or livestock, in a spatial arrangement, a rotation, or both, and in which there are usually both ecological and economic interactions between the trees and other components of the system. In simplified terms, agroforestry means combining the management of trees with productive agricultural activities. Agroforestry provides opportunities for forest conversion in the true sense of the term, replacement of natural forest with other tree-based land use systems. There are also opportunities to use agroforestry for the prevention or reversal of land degradation in the sub-humid and humid tropics.

It is also assumed that agroforestry might be a practical way to mimic the structure and function of natural ecosystems, since components of the latter result from natural selection towards sustainability and the ability to adjust to perturbations [1, 2]. Using agroforestry, with the ultimate aim of achieving sustainability of production and resource use [2]. However, despite the demonstration that such systems can dramatically reduce soil losses and improve soil physical properties, the beneficial effects on crop yield are often unpredictable and insufficient to attract widespread adoption. In semiarid areas, crop yield increases are rare in alley cropping because fertility and microclimate improvements do not offset the large competitive effect of trees with crops for water and nutrients [3].

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Intercropping in fruit orchards is a common practice in many countries. For example, intercropping of mustard with bananas and cucumber with citrus (mandarin) orchards improved the yields of mustard and cucumber without harming the yields of banana and Citrus in India [4]. Intercropping of legumes especially Egyptian clover in citrus orchards is beneficial for the citrus production. Similarly, soybean and chickpea improve fruit yield as compared to sole orchard. Such crops help increase the yield of the main crop by fixing nitrogen biologically in the soil [5, 6]. Furthermore, cover crops used in organic citrus orchards suppress weeds, and thus improved the yield of citrus fruit in Florida organic citrus orchards [7]. Similarly, French-beans intercropped with lemon (citrus) proved to be the best combination in India [8]. In Pakistan, it was observed that sowing maize in citrus orchard helped to improve the predators' popopulation that controls citrus leaf minor [9].

Agroforestry adds diversity to the farm plant population and results in increased cropping intensity and productivity of the orchards. Under agroforestry practice Intercropping is especially taken up in the young orchards which are yet to reach a commercial bearing age. The interspace between the fruit crops is utilized for growing short duration cash crops which not only sustain the orchardist during the non-fruiting months of the main crop but also add to the fertility of the soil by enhancing the soil health. Therefore, the aim of this study is to compare solid and inter-planted citrus with four winter field crops were compared to assess the effect of agroforestry of some field crops with citrus trees as which considered as an approach to establish biodiversity in fruit tree plantations.

MATERIALS AND METHODS

Four field crops i.e., lupin, wheat,canola and faba bean were inter-planted with seedless orange trees(4*4 m) in Kalubia, Egypt. The soil could be classified as loamy and the area were divided to inter-planted and solid plots for each crop. The irrigation system was drip and irrigation network included (1) Control head: It is located at the water source supply. It consists of centrifugal pump 4``/4``, driven by diesel engine (pump QRM charge of 100 m h and 50 m 3 1 lift), sand media filter 48`` (two tanks), screen filter 2`` (120 mesh) back flow prevention device, pressure regulator, pressure gauges, flow-meter, control (2) Main line: PVC pipes of 125 mm in diameter (OD) to convey the water from the source to the main control points in the field. (3) Sub-main lines: PVC pipes of 75 mm diameter (OD) were connected to with the main line through a control unit consists of a 2`` ball valve and pressure gauges. (4) Manifold lines: PVC pipes of 40 mm in diameter (OD) were connected to the sub main line through control valves 1.5``. (5) Emitters: These emitters Built in (GR) dripper from Polyethylene (PE) tubes 16 mm in diameter (OD) and 50 m in long (emitter QRM charge of 4 lph at 1.0 bar operating pressure, 0.3 m spacing between emitters, 1.0 m spacing between lateral lines. Crop selection included wheat (Gemmaiza 3),faba bean (Giza 3 variety), lupin (Giza 1 variety) and soybean (Giza82 variety). Fertilizers were applied according to the normal recommended rates in Egypt. Nitrogen phosphorus and potassium were applied as ammonium nitrate (33.5% N), calcium super phosphate (15.5% P^2 O^5) and potassium sulphate (48% K O), respectively according to the crop.

The yields of citrus fruit were assessed on each plot at the end of November. The number of fruit per tree and fruit weight were recorded, and production was determined. Samples of fruit were taken for chemical analysis. Citrus leaves were sampled from the same trees as were assessed for yield from solid and inter-planted plots. Citrus leaves were sampled from the same trees as were assessed for yield from solid and inter-planted plots. Five trees were selected at random on each plot and the number and weight of fruit determined, to provide average fruit production per tree and per plot. The yields of citrus fruit were assessed on each plot at the end of November. The number of fruit per tree and fruit weight were recorded, and production was determined. Samples of fruit were taken for chemical analysis. Citrus leaves were sampled from the same trees as were assessed for yield from solid and inter- planted plots.

Statistical Analysis: The data were subjected to statistical analysis of variance of split plot design was carried out using MSTAT-C Computer Software [10]. Means were compared by using least significant difference (LSD) at 5%.

RESULTS AND DISCUSSION

A) Yields: Table 1 provides an overall summary of the citrus fruit production and this shows that the yields are relatively poor, considering the fertile soil conditions. Mean fruit weight, no. of fruit per tree, mean yield per tree

Table 1: Yield characters of citrus in solid and agroforestry system.

Cropping system	Mean fruit weight (g)	Mean No. of fruit per tree	Mean yield per tree (kg)	Yield (t/fd)
Solid	110.4	160.2	15.492	4.056
Inter-planted	97.2	118.32	10.092	2.628
Overall mean	103.8	139.26	12.792	3.342

Table 2: Comparison of Crop Yields under Inter-planted and solid Production

Crop	Component	Inter-planted	Solid	Significance	Probability
Lupin	Seed	0.45	0.44	ns	0. 2628
	Straw	1.38	1.5	ns	0.0557
Wheat	Grain	2.01	1.92	*	0.0245
	Straw	6.5	6.49	ns	0.2266
Canola	Seed	2.62	2.36	*	0.0367
	Straw	8.93	8.56	ns	0.2274
Faba Bean	Seed	0.98	0.89	*	0.0549
	Straw	2.56	2.57	ns	0.8755

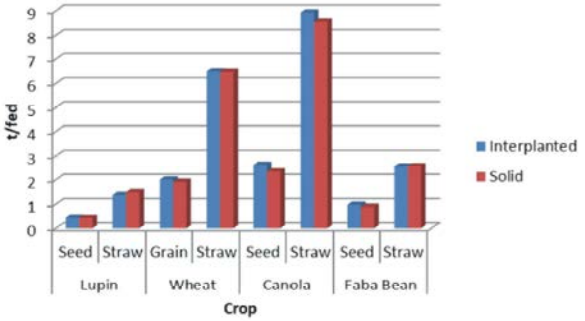

Fig. 1: Crop Yields under Inter-planted and solid systems

(kg) and yield (t/fd) under solid planting were greater than the inter-planted citrus.

Data presented in Table 2 show statistically significant effects ($P<0.05$) for wheat grains, canola and faba bean seeds. However, straw yields were not affected when inter-planted with citrus. Whilst inter-planted crops did not differ than the solid plantings the advantage of inter planting these crops with citrus except lupin increase yields by 9-11 % compared with solid plantings of these crops.

In theory, the potential of agroforestry to improve or increase biodiversity is efficient as the understorey crops are usually C4 species and the overstorey trees are invariably C3 species in agroforestry. However, under the circumstances all the crops under agroforestry of this trial are C3 plants. Improvement in interplant species is most likely if the understorey crop is a C3 species, which are usually light saturated in the open, and partial shade may have little effect on assimilation or by a concurrent reduction in transpiration. Similar results were obtained by [11] who reported that cotton yield in the Sahel was not reduced by the heavy shading of karite (*Vitellaria paradoxa*) and nere (*Parkia biglobosa*) in parklands while yields of millet and sorghum were reduced by 60% under the same trees [11]. Citrus is a nutrition responsive crop and intercropping of citrus orchards with the legume crops helps for fixing the nitrogen in the soil biologically [5, 6]. Further, in the organic citrus production, growing of intercrops suppresses the weeds and improves the fruit quality [7]. Intercropping is also associated with increased nutrient use efficiency for N, P and K while it had a positive effect on decreasing the soil erosion [12].

Table 3: Chemical Analysis of Citrus Leaf under inter-planted and solid cropping

Treatment	N	P	K	Fe	Mn	Zn	Cu
Intercropped	2.89	0.22	1.33	187	28.4	25.0	4.40
Solid	3.15	0.28	1.51	155	31.2	25.3	4.70
CV%	13.4	19.3	23.3	16.6	5.8	1.5	7.7
Minimum	2.52	0.17	0.90	138	27.5	25.0	3.90
Maximum	3.43	0.31	1.75	216	31.4	25.9	4.80

Some investigators reported that Planting of wheat and berseem as intercrops adversely affected the yield of citrus due to the competition for nutrients and different requirements of irrigation and nutrients of the crops [6, 13, 14]. Similar trends were observed for per plant yield. It was found that per plant yield of the orchard without intercropping was 14 kg (24 percent) greater than those which were intercropped. These results confirm to the earlier results of [6], and [13, 14]. Intercrops add to the carbon pool of the soil thus enriching the soil with organic carbon. Research also shows that intercropping with gliricidia in maize resulted in 12% higher soil organic carbon (SOC) as compared to sole maize plantation [15], although the effect of intercropping on carbon sequestration depends on cultural practice systems [16].

B) Nutritional Status: Leaf and fruits of citrus as well as the inter-planted crops were analyzed for macro and micro nutrients according to the methods described by [17]. The summary given in Table 3 and Fig. 2 shows that whilst there may be a small benefit of inter-planted crops to the leaf content of NPK. The tissue concentrations of micronutrients are within the normal ranges expected for all of these elements, although zinc and copper were marginally deficient.

Figure 2 shows Macro nutrient concentration % of citrus leaf and fruit under solid and inter-planted cropping systems. The data clearly indicate that nearly two folds of N in leaf compared with fruit only while P and K concentrations were similar either in leaf or fruit. Table 4 and Fig. 3 clearly show that N translocation from citrus

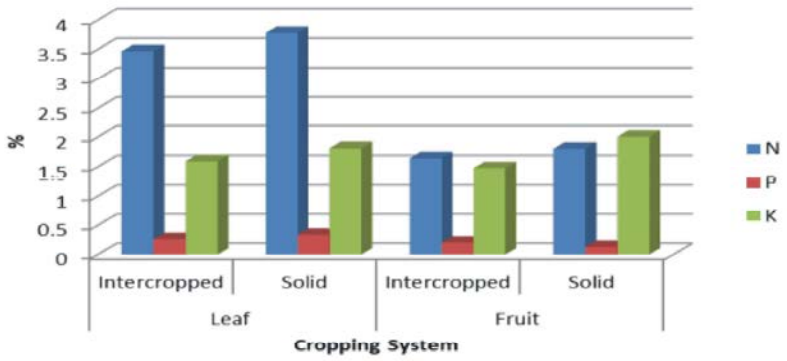

Fig. 2: Macro nutrient concentration % of citrus leaf and fruit under solid and inter-planted cropping systems

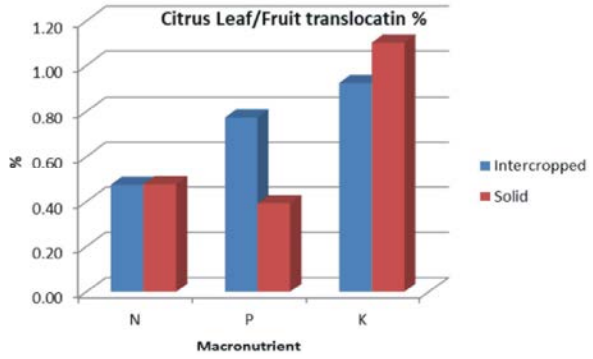

Fig. 3: NPK translocation (%)from leaf to citrus fruit under cropping systems

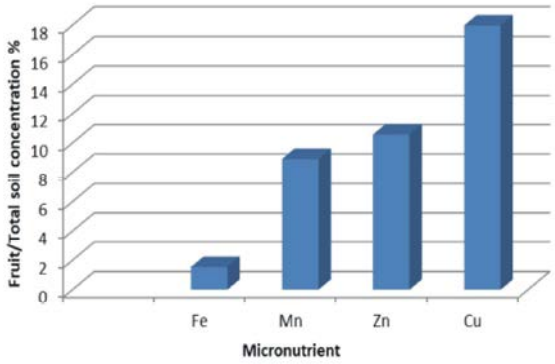

Fig. 4: Micronutrient concentration translocation ratio (fruit/total soil concentration %)

Table 4: Macro nutrient concentration % of citrus leaf and fruit under solid and inter-planted

Plant part	Cropping system	N	P	K
Leaf	Intercropped	3.468	0.264	1.596
	Solid	3.78	0.336	1.812
Fruit	Intercropped	1.644	0.204	1.476
	Solid	1.8	0.132	2.004

Table 5: Statistical summaries of total and extractable trace elements in soil and concentrations in citrus fruit (n=15)

Parameter	Fe	Mn	Zn	Cu
Total soil concentration (mg kg^{-1})				
Minimum	3120	330	180	50
Maximum	16820	540	530	117
Mean	10948	429	331	84
Median	11680	440	310	82
DTPA extractable soil concentration (mg kg^{-1})				
Minimum	88	14.8	16	8
Maximum	232	54.6	56	27
Mean	169	38.2	35	15.1
Median	176	40.3	32	13.5
Tissue concentration in citrus fruit (orange and mandarin) (mg kg^{-1} DM)				
Minimum	2.4	0.37	0.37	0.12
Maximum	20.4	3.8	2.6	0.48
Mean	8.42	1.6	1.06	0.25
Median	6	1.6	1	0.24

Leaf to fruit was similar while P under inter-planting was greater than the solid planting, K was greater in solid planting than inter-planting. Comparing micronutrients translocation the results shown in Fig. 4 reveal that micronutrient translocation from soil to citrus fruits followed the order Cu > Zn > Mn >Fe. In this respect it was reported that the intercropping with cowpea increased the NPK content in guava leaf as against the sole crop. The increase in the leaf N, P and K was due to the increase in the availability of nutrients in the soil by the attributed huge amount of biomass by intercrop. It was also found that leaf NPK was higher with the leguminous intercrops and lower in solid culture. The incorporation of biomass by intercrops helped for improving the biological, chemical and physical status of soil which may have helped for better uptake of soil nutrients by the findings of [18,19].

Soil-Leaf- Fruit Relationship under Agroforestry System: From this study it is concluded that intercropping does not have beneficial effect on citrus. Inter-planted crops did not reduce the fruit drop but

affected yield, fruit quality, growth parameters, soil fertility, soil health and leaf NPK status. The leguminous crops have more intensity on the soil properties for improving the biological environment. Intercrops also improved the chemical composition of fruit which was desirable quality from consumers. It is recommended to grow intercrops in citrus plantations for better quality of fruits, improving physio-chemical properties of soil and also for complete utilization of all input resources. However, the selection of suitable crop and skillful knowledge is required for the cultivation of intercrops for reducing effect on main crop and better economic feasibility. Similar results were reported by several investigators [20-23].

REFERENCES

1. Van Noordwijk, M. and P. Purnomosidhi, 1995. Root architecture in relation to tree-soil-crop interactions and shoot pruning in agroforestry. Agroforestry Systems 30: 161-173.
2. Young, A., 1997. Agroforestry for Soil Management. CAB International, Wallingford, UK.
3. Rao, M.R., P.K.R. Nair and C.K. Ong, 1997. Biophysical interactions in tropical agroforestry systems. Agroforestry Systems, 38: 3-50.
4. Ouma, G. and P. Jeruto, 2010. Sustainable horticultural crop production through intercropping: The case of fruits and vegetable crops: A review. Agric. Biol. J. N. Am., 1: 1098-1105.
5. Aziz, R.A.A., S.E. Salem and L. Al-Bitar, 2008. Effect of intercropping cover crops on citrus orchards growth and fruiting under Toshka conditions. J. Agric. Vet. Sci., 1: 101-110.
6. Srivastava, A.K., A.D. Huchche, L. Ram and S. Singh, 2007. Yield prediction in intercropped versus mono-cropped citrus orchards. Scientia Hort., 114: 67-70.
7. Linares, J., J. Scholberg, K. Boote, C.A. Chase, J.J. Ferguson and R. McSorley, 2008. Use of the cover crop weed index to evaluate weed suppression by cover crops in organic citrus orchards. Hort. Sci., 43: 27-34.
8. Hnamte, V., B. Gopichand and F. Lalnunmawia, 2013. Study on economic feasibility of intercropping of lemon (*Citrus limon* Burm) with vegetables in the hilly terrain of Mizoram. Science Vision, 13: 40-44.
9. Ahmed, S., M.A. Khan and M. Qasam, 2013. Effect of intercropping of maize in citrus orchards on Citrus Leaf Miner infestation and population ofits natural enemies. Pak. J. Agric. Sci., 50: 91-93.
10. MSTAT-C, 1988. MSTAT-C, a microcomputer program for the design, arrangement and analysis. Michigan State University, East Lansing.
11. Kater, L.J.M., S. Kante and A. Budelman, 1992. Karité (*Vitellaria paradoxa*) and néré (*Parkia biglobosa*) associated with crops in South Mali. Agroforest Syst., 18: 89-105. https://doi.org/10.1007/BF00115407
12. Singh, S.K., M. Sharma and P.K. Singh, 2016. Intercropping- An approach to reduce fruit drop and improve fruit quality in guava. J. Chem. Pharm. Sci., 9(4): 3182-3187.
13. Lachungpa, K., 2004. Intercropping of agri/horti crops with special reference to mandarin (*Citrus reticulata* Blanco) in Sikkim, India. Presented at 4th Int. Crop Sci. Cong., Brisbane Australia. Online available at http:// www.cropscience.org.au/icsc2004 /poster/2/3 /1954_lachungpak.htm. Accessed on 05/09/2013.
14. Khan, A.R. and M. Tariq, 2010. Situation analysis report on citrus quality deterioration in district Sargodha. Directorate of Agricultural Information Punjab. Research Information Unit, Faisalabad, Pakistan.
15. Beedy, T.L., S.S. Snap, F.K. Akkinnifesi and G.W. Sileshi, 2010. Impact of *Gliricidia sepum* intercropping on soil organic matter fractions in a maize based cropping system. Agriculture Ecosystems and Environment, 138: 139-146.
16. Hairiah, K., V.M. Noordwijk and G. Cadisch, 2000. Crop yield, C and N balance of three types of cropping systems on an Ultisol in Northern Lampung. Neth. J. Agri. Sci., 48: 3-7.
17. Chapman, H.D. and F.E. Pratt, 1961. Methods of Analysis of Soil, Plant and Water. University of California, USA.
18. Maheswarappa, H. P., M. B. Hegda, R. Dhanapal, and C. Biddappa. 1998. Mixed farming in Coconut garden: Its impact on soil physical, chemical properties, coconut nutrition, and yield. Journal of Plantation Crops, 26(2): 39-143.
19. Ghosh, S.N., and P.P. Pal, 2010. Effect of inter cropping on plant and soil of mosambi sweet orange orchard under rainfed conditions. Indian Journal of Horticulture, 67(2): 185-190.
20. E.M. Abd El-Lateef, A.A. Yaseen, M.S. Abd El-Salam, A.K.M. Salem and Aml R.M. Yousef, 2021. New Crops to Increase Diversity in Egyptian Cropping Systems. International Journal of Sustainable Agriculture, 9(1): 01-05.

21. E.M. Abd El-Lateef, M.S. Abd El-Salam, A.A. Yassen, Sahar M. Zaghloul, A.K.M. Salem, T.A. Elewa and Aml R.M. Yousef, 2021. Bioavailability of Trace Elements and Heavy Metals in of Some Forestry Species Leaves under Desert Conditions of Egypt. American-Eurasian J. Agric. & Environ. Sci., 21(3): 178-187.
22. E.M. Abd El-Lateef, A.A. Yassin, T.A. Elewa, A.K.M. Salem and M.S. Abd El-Salam, 2020. Effect of Fertility Stress Mitigation on Cotton (*Gossypium barbadense L.*) Yield and Nutrient Status under Calcareous Soil Conditions. American-Eurasian Journal of Agronomy, 13(2): 21-29.
23. E.M. Abd El-Lateef, A.A. Yaseen, Sahar M. Zaghloul1M.F. El-Karamany and M.S. Abd El-Salam, 2021. Effect of Soybean (*Glycin max merril*) Irrigation with Reclaimed Wastewater on Seed Yield and Quality. Academic Journal of Plant Sciences, 14(1): 01-06.