www.kosmospublishers.com
contact@kosmospublishers.com

Research Article | Advances in Agriculture, Horticulture and Entomology | AAHE-101

Efficacy of Multilayer Cropping on Fig Production in Arid Conditions of Kuwait

Hani A Al-Zalzaleh*, Gladson Dcruz

Desert Agriculture and Ecosystems Program, Environment and Life Sciences Research Center, Kuwait Institute for Scientific Research, Kuwait

Received Date: December 02, 2019; **Accepted Date:** December 10, 2019; **Published Date:** December 19, 2019

***Corresponding author**: Hani A Al-Zalzaleh, Desert Agriculture and Ecosystems Program, Environment and Life Sciences Research Center, Kuwait Institute for Scientific Research, Kuwait. Email: hzalzale@kisr.edu.kw

Abstract

An experiment to assess the influence of intercropping on the growth and performance of figs in a multilayer system of planting was carried out under the arid climatic conditions of Kuwait. The experiment was laid out in a Randomized Block Design comprising of two treatments with six replications in two sites. The two treatments were fig plants intercropped with or without vegetables. The main tree date palm was planted with a spacing of 7 X 7 m and the vegetables were planted in between the lines of fig trees. The results of the study revealed that date palm +fig +vegetables multitier system exhibited better performance, which was reflected in the significant ($p<0.05$) increase of the soil nutrients, growth parameters and fruit quantity and quality than the fig plants without vegetables. Even though the trees were in initial orchard years and still young, fruit yield in terms of number of fruiting shoots, number of fruits, weight per fruits, and average yield per tree, the response to inter planting with vegetables was significant. Based on these results, it could be concluded that intercropping technique in date palm plantations along with figs and vegetables resulted in maximizing the use of unit land. Nevertheless, fruit quality of fig was influenced by the intercropping systems, which was considered to be a good sign for farmers in adapting and promoting inter planting practices.

Keywords: Date Palm; Inter-Planting; Irrigation; Microclimate; Vegetables

Introduction

Fig belongs to the *Moraceae* **[1]** family and is among the earliest cultivated fruit trees in the world **[2]**.Today, it is an imperative world crop and has been cultivated in Turkey, Egypt, Morocco, Spain, Greece, California, Italy, Brazil, and other places with typically mild winters and hot dry summers **[3]**.

Kuwait's climatic conditions are harsh and are typical of an arid environment characterized by high temperature during summer, very low rainfalls, frequent winds, sand storms, and soil erosion. This limitation coupled with progressive buildup of salts in the soil hinders the growth of a wide range of plants. Hence, the State of Kuwait is making efforts to strengthen agricultural production and achieve partial food security in selected commodities. To achieve these goals, many types of figs has planted in home gardens and in designated areas in Kuwait. The suitability of the land for fig production, combined with positive farmer perception, indicates that there is a potential for the development of this plant on a commercial basis.

Materials and Methods

The inter cropping experiment was conducted during April to September of 2018in an existing 10-year-old bearing date palm plantation site at Public Authority for Agriculture and Fish Resources (PAAFR), located at Wafra. The experimental sites with enough plant-to-plant spacing were selected to assure a good shade. Out of the two areas, one area planted with Medjool date palms was selected as "Site 1" and the other with Barhi palms as "Site 2". The experiment was arranged in a randomized complete block design (RCBD) with two treatments and 6 replications in each site. In both of the sites, the grafted seedlings of seven selected cultivars namely Black Mission, Brown Turkey, Calimyrna Red, Calimyrna White, Sequoia, Sierra, and Tina, were planted in between the date palms at a spacing of 4 m,and vegetables were planted in between the lines of fig trees. In short, there were two treatments, such as the interspacing area between date palms and figs planted with leafy vegetables and without vegetables. Similarly, there were two sites, and the vegetables were planted in two seasons.

In the first season, two leafy vegetables, parsley or garden parsley (*Petroselinum crispum*) and arugula or rocket (*Eruca sativa*), were planted on the inter rows of date palms as single stripe, and each stripe were started 10 cm away from the basins of the fig plants. In intercropping, each row of fig was inserted between every rows of the parsley or arugula. In the second season, common purslane (*Portulaca oleracea*) and basil (*Ocimum basilicum*) were planted as interplant with fig plants. For the cultivation of these vegetables, a seedbed was prepared by ploughing the land twice at depth of 30 cm. The ploughing was carried out perpendicular to the space in between the fig plants and to prevent the runoff and improve water retention; basins were prepared around this prepared land. The seeds of all the four vegetables were broadcasted in the prepared areas and irrigated using adjustable drippers. However, no organic or inorganic fertilizers were given to the fig plants until the end of the experiment.

The plant height of fig trees was estimated by measuring the length of the main stem at the beginning and at the termination of season. Stem thickness of each plant was measured using a caliper at the 10-cm height of the plant above the ground surface. Leaf area was calculated on selected four leaves from each plant and expressed as centimeter squared. In the first week of July, the number of fruiting shoots were counted and recorded. The fruits were harvested at the peak of the color development (second week of August), and recorded number of fruits, fruit weight (g.) and yield/plant (g). The growth rate of each plant was calculated using the equation as follows:

$$\text{Growth rate} = [(\text{Final total growth} - \text{Initial total growth}) / \text{Initial total growth}] \times 100 \quad (1)$$

The soil samples were analyzed for soil physical and chemical variables at the PAAFR laboratories, Kuwait. The percentages of N, P, K and Mg in plant leaves were determined according to the procedures that outlined by USDA, 2004. Total phenolic compounds of each sample were extracted by the Folin–Ciocalteu's method as described by and total flavonoid content was measured by aluminum trichloride assay **[4, 5]**.

Results and Discussion

Nutrient Status of Fig Plants

From the data in **(Table 1)**, it is clear that the intercropping practices resulted in the improvement of favorable physical conditions and nutrient status of the soil. Intercropping fig plants with vegetables caused a substantial reduction of EC from 5.21 to 3.80 mS/cm, thereby making the major nutrients available to the fig plants, which reflects in the vegetative growth of plants under intercropping than the other treatment. Similarly, the lowest values of pH were noticed under intercropped areas, which enable smooth retention and availability of the plant essential nutrients.

Treatments	pH	ECe (mS/cm)	Water Soluble Cations (Meq/L)				Water Soluble Anions (Meq/L)			SO_4	PO_4	NO_3
			Ca	Mg	Na	K	CO_3	HCO_3	Cl	(ppm)		
Fig + vegetables	7.1	3.80	10	4.5	9.25	5.5	1.9	4.6	16.4	24.0	37.6	42.6
Fig -vegetables	7.9	5.21	12	1.3	14.4	2.8	0.7	4.2	21.5	21.4	12.4	28.2

Table 1: Soil Chemical Properties as Affected by Intercropping of Fig Plants with Vegetables.

The soils of fig plants intercropped with vegetables had a high concentration of major nutrients compared to pure stand of figs. Even though there was an uptake of nutrients by the main and sub crops, a high content of nitrogen was observed in rhizosphere of intercropped plants. The increase in the available nitrogen content of soil might be due to greater recycling of bio-mass in the inter space with higher percentage of nitrogen in the vegetable based inter cropping system as compared to sole cropping systems **[6]**. According to Thorup-Kristensen and Sorensen (1999)**[7]**, the planting of shallow rooted crops as intercrop with deep rooted crops where available N is present in deeper soil layers, nitrogen availability can be increased. This increase in available nitrogen content of the soil can be because of the in sit incorporation of intercrops biomass and increased the enzymatic activity of the effective microorganisms, which leads to the release of nutrients in the soil. Swain and Patro (2007) also reported an increased available nitrogen content of the soil through intercropping in mango intercropping systems. The available phosphorus content of soil under intercropping systems might be due to increase in the phosphorus solubulizers due to the incorporation of vegetable biomass. Swain and Patro (2007) also observed similar findings on beneficial effect of inter cropping in increasing the availability of phosphorus in the soil. The intercropping of vegetables also increased the K levels in soil, which in turn provided resistance to plants to thrive prevailing drought conditions. The results also indicated that the intercropping system were advantageous in increasing the available potassium contents of soil, which corroborates with the findings of Swain and Patro (2007) **[8]**. This recycling of biomass had increased the content of humus in the soil and thereby increased the available potassium content. Previous studies of Maheswarappa et al., (1998) **[9]** also supported these findings by their results of improvement in major nutrient status of soil due to intercropping.

Plant Growth of Fig

Results of intercropping of fig plants with vegetables and sole cropping of figs on some vegetative parameters displayed that there was statistical difference between the intercropping and sole cropping($p<0.05$)on relative growth rate and leaf area, while there was no difference on plant height, stem thickness in both the sites. Nevertheless no significant variation was found between the two sites in any of the vegetative parameters studied. The highest plant height, stem thickness, relative growth rate and leaf area were obtained from intercropped areas. While the highest relative growth (27.9) was obtained from fig plants inter planted with vegetables in site 2, sole cropping of fig plants (26.6) from site 1 followed it. The fig plants with vegetables intercropped surpasses the sole cropped plants in the leaf area in both sites. The sites and intercropping interactions had statistically significant effect ($p<0.05$) on the leaf area only. The maximum leaf area was obtained from the leaves of fig plants planted in intercropped areas in both the sites. In general, the intercropping of fig plants with vegetables significantly higher than the sole cropping of figs in some of the primary growth characteristics. These results are in accordance with the findings of Aksoy et al., (1987) **[10]**.

The results of the studies showed that the vegetative growth characteristics of fig plants were positively influenced by intercropping. The reason for increase in growth parameters of fig plants might be due to this input utilization. According to Panda et al. (2003) **[11]**, adoption of suitable intercropping systems in fruit crops aids in efficient utilization of available natural resources and there by improves the inputs efficiency in the system. Intercropping with nitrophilous crops particularly with purslane was helpful in the positive effective increase in nitrogen that results in higher vegetative growth in fig plants. More research findings supporting the observations on increase in tree height, girth, and canopy area of fruit crops due to intercropping were reported by Singh et al., (1996)**[12].**

Fruit Weight and Yield of Fig Plants

Even though the fig trees were in initial orchard years and still yielded young fruit in terms of number of fruiting shoots, number of fruits, weight per fruits, and average yield per tree in response to inter planting with vegetables was significant. Plants represented the intercropped area produced more fruiting shoots, fruits, fruit weight, and yield per tree than in areas where vegetables were not planted as intercrops in both the sites. However, statistical variation among the sites and the interaction of sites and treatments were observed in the fruit characteristics of number of fruits per plant and yield per tree. Intercropping practices with vegetables in site 1 had the significantly higher number of fruits per plant (12.4) and yield per tree (466.7) compared to those in site 2. Regarding the interaction effect of sites and treatments, intercropping vegetables with fig plants in site 1 produced significantly more number of fruits per plant (12.8) and yield per tree (484.2) than the other studied interaction treatments under study.

The data showed that the intercropping of date palm, figs, and vegetables significantly increased all the fruit characteristics under study. This result may be due to the fact that the palm tree provided enough space for the filler crop (figs) and the interplants (vegetables) to get favorable conditions for growth. Akyurt et al.(2002) **[13]** found that date palm supply enough space for intercropping even if they are fully grown as they do not cover much area being very tall tree. Aksoy (1998) **[14]** reported that the competition for resources between the component crops and the efficient utilization of natural resources like solar radiation, soil moisture, and nutrients may be the reasons for the higher yield parameters particularly fruit weight and fruit yield under intercropping systems. Moreover, the cultural practices followed for the intercropped areas contributed to the higher production of fruits **[15, 16]**. However, according to Ali et al., (1998) **[17]**, the date palms could be intercropped with citrus and are possible to be grown as a mixed fruit orchard. Previous studies by different researchers concluded that intercropping those trees that are cultivated with various intercrops had no considerable adverse effects on the yield and fruit quality of main crops **[18, 19]**.

Fig Fruit Quality

Results of total phenolic and total flavanoide contents of the treatments are shown in **(Table 2)**. The methanolic extracts of fig leaves from vegetable intercropped areas contained the significantly highest amounts of total phenolic and flavanoid compounds than the other treatments. A higher amounts of phenolic compounds with a value of 46.270(mg GAE/g DE) were obtained from the intercropped with vegetable areas in site 1 and 43.194 (mg GAE/g DE) from the intercropped areas in site 2. Similarly in this study, the highest amounts of flavonoids were noted in leaves of fig and vegetables intercropping areas with 16.393and 15.932mg QE/g DE in Site 1 and Site 2, respectively.

Intercropping Treatments	Plant Growth Characteristics							
	Site 1				Site 2			
	Plant Height (cm)	Stem Thickness (cm)	Relative Growth Rate (%)	Leaf Area (cm^2)	Plant Height (cm)	Stem Thickness (cm)	Relative Growth Rate (%)	Leaf Area (cm^2)
Fig +vegetables	174.2	4.6	26.6	95.7	174.1	4.7	27.9	94.6
Fig - vegetables	172.5	4.6	25.3	82.4	174.0	4.5	25.5	86.9
Site 1	173.4	4.5	25.9	89.1				
Site 2	174.2	4.6	26.7	89.9				
Site (S).	NS	NS	NS	NS				
Treatments (T).	NS	NS	*	*				
S*T.	NS	NS	NS	*				

	Yield Attributes							
	No. of Fruiting Shoots	No. of Fruits per Plant	Fruit Weight (g)	Yield/ Tree (g)	No. of Fruiting Shoots	No. of Fruits per Plant	Fruit Weight(g)	Yield/ Tree(g)
Fig + vegetables	5.93	12.82	39.63	484.2	5.36	12.10	37.27	450.40
Fig - vegetables	5.13	11.98	37.71	449.2	4.66	11.19	36.91	435.34
Site 1	5.53	12.40	38.67	466.7				
Site 2	5.01	11.65	37.09	442.8				
Site (S).	NS	*	NS	*				
Treatments (T).	*	*	*	*				
S*T.	NS	*	NS	*				

	Fruit Quality			
	Total Phenolics (mg GAE/g DE)	Total Flavonoids (mg QE/g DE)	Total Phenolics (mg GAE/g DE)	Total Flavonoids (mg QE/g DE)
Fig +vegetables	46.270	16.393	43.194	15.932
Fig -vegetables	44.675	15.976	41.543	14.895
Site 1	45.472	16.185		
Site 2	42.369	15.413		
Site (S)	NS	NS		
Treatments (T).	*	NS		
S*T.	NS	NS		

	Leaf Macronutrient Contents (% Dry Weights)									
	N	P	K	Ca	Mg	N	P	K	Ca	Mg
Fig +vegetables	1.77	0.14	1.07	3.59	0.85	1.69	0.15	1.10	3.60	0.88
Fig -vegetables	1.68	0.10	1.06	3.53	0.83	1.63	0.11	1.08	3.56	0.83
Site 1	1.72	0.12	1.07	3.56	0.84					
Site 2	1.65	0.13	1.09	3.59	0.85					
Site (S).	*	NS	NS	NS	NS					
Treatments (T).	*	NS	*	*	NS					
S*T.	NS	NS	NS	NS	*					
* denotes the significant difference at $p<0.05$; NS- Non-significant.										

Table 2: Fig growth and yield parameters as affected by interplanting of fig trees with vegetables.

The analysis of quality parameters of fig plants in **(Table2)** revealed that there was no appreciable influence on fruit quality by intercropping practices. The fruit quality aspects such as total phenolic acids showed significant differences while there was no difference in total flavonoids between the treatments. Previous studies in fig showed that fruit quality parameters were unaffected by planting distances **[20, 21]**. Similar results were obtained from the researches of Kanwar et al.(1993), and Ghosh (2001) **[15,22]**, where the quality of fruits were not affected due to growing of intercrops, in mango, citrus, and guava orchards.

Leaf Macronutrient Contents

Results clearly revealed that the different nutrients in the fig leaves were significantly varied in the main effects of nitrogen, potassium, and calcium contents. Regarding the interaction effect of sites and treatments significant variation was found in the content of Magnesium. Intercropping of fig plants with vegetables significantly increased the contents of four macronutrients compared with the figs without intercropping. A gradual and significant increase in the contents of nitrogen, potassium, calcium, and magnesium contents were recorded with growing figs with vegetables. These trends of nutrient increment were true in both the sites.

The leaf analysis results of the study indicated that the N, K, Mg, and Ca contents of the leaves of fig plants were maximum under fig and vegetable intercropping system. The availability of nutrients in the soil is increased due to the in sit incorporation of vegetable residues might be the reason for the increase in the major plant nutrient status of fig leaves when compared to the fig plants without intercropping. Maheswarappa et al. (1998) concluded that the incorporation of intercrops residues might be helpful in improving the soil physical, chemical, and biological environments, which in turn favors the higher uptake from the nutrient pool in the soil.

Conclusions

Multilayer cropping is becoming a sustainable crop production technique by utilizing a number of environmental beneficial effects and effective utilization of available land for diversifying agricultural outcome. High, medium, and low plants were integrated in a most sustainable manner in this production model. From the results of the study, it was revealed that intercropping was the ideal practice in increasing the plant growth and fruit yield of fig plants. The plant growth, fruit weight, and fruit yield of fig were found significantly higher in intercropping with vegetables under the canopy of date palms. Nevertheless, fruit quality of fig was influenced by the intercropping systems, which was considered a good sign for farmers in adapting and promoting interplanting practices. The introduction of intercropping technique in date palm plantations along with figs and vegetables resulted in maximizing the use of unit land. The results of the study also conclude that intercropping of fig plants and vegetables with date palm indicated that these techniques of intercropping could be used for combating desertification in the arable sandy soils of Kuwait.

Acknowledgments

The project team would like to thank the Kuwait Foundation for the Advancement of Sciences (KFAS-(P116-12SL-04) and the management of the Kuwait Institute for Scientific Research (KISR) for their continued encouragement and the financial support extended to the project.

References

1. Vallejo F, Marin J, Barberan TF (2012) Phenolic compound content of fresh and dried figs (Ficus carica L.), Food Chemistry 130: 485-492.
2. Solomon A, Golubowicz S, Yablowicz Z, Grossman S, Bergma M, et al. (2006) Antioxidant activities and anthocyanin content of fresh fruits of common fig (*Ficus carica*L.), Journal of Agriculture and Food Chemistry 54: 7717-7723.
3. Zohary D, Hopf M (2000) Domestication of Plants in the Old World, 3rd ed.; Oxford: Clarendon.
4. Fu L, Xu BT, Gan XR, Zhang RY, Xia EQ, et al. (2011) Antioxidant capacities and total phenolic contents of 62 fruits, Food Chemistry 129: 345-350.
5. Koolen HHF, da Silva FMA, Gozzo FC, de Souza AQL, de Souza ADL (2013) Antioxidant, antimicrobial activities and characterization of phenolic compounds from Buriti (*Mauritia flexuosa* L), Food Research International 51: 467-473.
6. Manna MC, Singh MV (2001) Long-term effects of intercropping and bio litter recycling on soil biological activity and fertility status of subtropical soils, Bioremediation Technologies 76: 143-150.
7. Thorup-Kristensen K, Sorensen JN (1999) Soil Nitrogen Depletion by Vegetable Crops with Variable Root Growth, Acta Agriculturae Scandinavica, Section B. Soil and Plant Science 49: 92-97.
8. Swain SC, Patro L (2007) Horticulture based cropping system–A strategy for sustainable development in rainfed upland, In: Environmental Hazards; Patro, L., Tripathy S. N., (Eds), Sonali Publication, New Delhi, pp 44-69.
9. Maheswarappa HP, Hegda MB, Dhanapal R, Biddappa C (1998) Mixed forming in coconut garden–Its impact on soil physical, chemical properties, nutrition and yield, Journal of Plantation Crops 26: 139-43.
10. Aksoy U, Anac D, Hakerlerler H, Düzbastilar M (1987) The nutritional status of fig (cv Sarilop) orchards of the Germenik district and the relationship between nutrition, yield and some quality properties, Project no. 006, Ege University, Faculty of Agriculture, Turkey.
11. Panda MM, Nandi A, Bhoi N, Senapati N, Barik KC, et al. (2003) Studies on identification of suitable intercrops for degraded land management in the North Central Plateau Agro-climatic Zone of Orissa, Journal Research of Orissa University of Agriculture and Technology 21: 62-66.
12. Singh J, Kashyap R, Sharma DP (1996) Effect of cultural practices and intercropping on growth and economic yield of mango orchard cv. Langra, Indian Journal of Horticulture 53: 290-94.
13. Akyurt M, Rehbini E, Bogis H, Aljinaidi AA (2002) Survey of mechanization efforts on date palm operations, Sixth Saudi Engineering Conference, Dhahran, December 2002, Pp 475-489.
14. Aksoy U (1998) Why figs? An old taste and new perspective, Acta Horticulturae 480: 25-26.
15. Ghosh SN (2001) Intercropping in guava orchard in watershed area, Horticulture Journal 14: 36-40.
16. Rath S, Swain SC (2006) Performance of intercrops in bearing mango orchards in Eastern Ghat High land zones of Orissa, Indian Journal of Dryland Agricultural Research and Development 21: 12-15.
17. Ali GA, Karbl AK, Ibn-Aoof M (1998) Survey on production, handling, storage, and marketing of dates in the northern region, First International Conference on Date palms,Al- Ain, UAE 1998: 8-10.

18. Ashour NI, Saad AOM, Abou Rayya MS, Maksoud HK, Kabesh MO (1994) Application of scientific results in developing crop production in North Sinai, Academy of Scientific Research and Technology, Project No.3, Cairo, Egypt.
19. Abouziena HFH, Abd EI-Motty Elham Z, Youssef RA, Salah AF (2010) Efficacy of intercropping mango, mandarin and Egyptian clover plants with date palm on soil properties, rhizosphere microflora and quality and quantity of date fruits, Journal of American Society of Science 6: 230-238.
20. Kumar R, Ganesh S, Chitraichelvan R, Upretti KK, Sulladmath VV (2011) Effect of spacing and pruning on growth, yield and quality of fig, Journal Horticulture Science 9: 31-37.
21. Hosomi A, Miwa Y, Mano T (2013) Shoot Growth and Fruit Production of Masui Dauphine Fig Trees Having High Limb Position with Downward Shoots, Journal of the Japanese Society of Horticulture Science 82 : 215-221.
22. Kanwar JS, Brar SS, Chopra HR (1993) Status of intercropping of orchards in Punjab, Punjab Horticulture Journal 34: 1163-1176.

Citation: *Al-Zalzaleh AH, Dcruz G (2019) Efficacy of Multilayer Cropping on Fig Production in Arid Conditions of Kuwait. Adv Agri Harti and Ento: AAHE-101.*