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Effects of Intercropping on Plant Nutrient Uptake in Various Vegetables Species

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The objective of this study was to determine the effect of intercropping system on some vegetables nutrient uptake in Adana ecological conditions. The experimental research was conducted under field conditions and at the plant physiology laboratory of the Department of Horticulture, Faculty of Agriculture of Cukurova University during 2003-2005. In the first year of this work, cauliflower and broccoli, in the second year cauliflower, cabbage and lettuce were used as main crop. Lettuce, pea, leek, garlic and onion were used as intercrops in the first year; green bean, pea, radish, leek, garlic and onion were used as intercrops in the second year. In general, it can be said that the vegetables cropped solely uptaked more mineral contents while for those grown by intercropping and competitions were determined in intercropped systems.

Key Words: Intercropping, Vegetables, Plant nutrient uptake.

INTRODUCTION

Vegetables are important food sources for human nutrition and they are especially important to provide necessary vitamins and minerals. Therefore, consumption and diversification of vegetables have been increasing steadily throughout in the world as well as in Turkey.

In Turkey according to 2005 data, total vegetable area was 1048803 ha and vegetable production was 25395111 tones[1].

Malnutrition and hunger are two important problems threatening humanity worldwide. In order to combat these problems it is necessary to increase out put of food production. In developing countries these problems becoming more immenent since population has been growing faster than that of food production in those countries[2]. It is necessary and the only way, to increase the out put of food production from cultivated lands because of the limited lands in the world[3].

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It is not possible to increase the yield by increasing cultivated lands. The only way is to increase yield from lands that have been used for vegetable production. Increasing production could be accomplished by increasing inputs, such as fertilizers and pesticides, but this approach may not be the best suited model since most farms are small and cannot cope with increased costs and there will be environmental consequences[4].

Monocultures causes increased use of inorganic fertilizers to maintain and increase yield from per hectare, thus they negatively effect water quality due deposition of fertilizers and soil fertility. These, in return, could cause erosion and salinization of fertile lands. In order to prevent such events, it is necessary to develop alternative strategies[5]. Sustainable land management of agricultural systems should maintain production, minimise risks, preserve soil and water quality and be economically feasible and socially acceptable[6].

The performance of component crops in intercropping systems differs from that in monoculture cropping. Intercropping is widely accepted as a sustainable practice due to its yield advantage, high utilization efficiency of light and water and pest and disease suppression[7-9]. Currently, this system is attracting in low-input crop production systems and is being extensively investigated[10,11]. Interspecific root interactions affect nutrient mobilization in the rhizosphere and contribute efficiently to nutrient acquisition by intercropping. Intercropping is also effective in improving mobilization and uptake of micronutrients[10,12]. Intercropping also affects the utilization of other minerals in the rhizosphere, such as Ca and Mg[10].

The aim of the present study was to determine the effect of intercropping system on the plant nutrient uptake of some vegetables.

EXPERIMENTAL

This study was conducted under field conditions of the Department of Horticulture, Faculty of Agriculture, Cukurova University during 2003-2005.

The first year of this work cauliflower (Tefris cv.) and broccoli (AG 3317 cv.), the second year, cauliflower (Barcelona cv.), cabbage (Megaton cv.) and lettuce (Lital cv.) were used as main crops. The intercrops in the first year was letttuce (Lital cv.), onion (Aki cv.), garlic (Kastamonu cv.), leek (Tarsus Yerli cv.) and pea (Utrillo cv.), the second year because lettuce were used as a main crop, the intercrops were onion (Aki cv.), garlic (Birecik Yerli cv.), leek (Tarsus Yerli cv.) and pea (Utrillo cv.). Supplementary radish (Balcali cv.) and bean (Gina cv.).

In the first year of the study, the principles plots was determined as 1.5 m × 5 m = 7.5 m^2. Cabbage and cauliflower were planted in this parcels with 0.75 m × 0.50 m distance and 20 plants were occured in each parcel.

Onion, leek, pea and garlic were planted in main plots as two rows and lettuce was planted as a single row. Distance within and between rows were 25 cm × 10 cm for onion, garlic and leek, 40 cm × 40 cm for lettuce and 25 cm × 25 cm for pea in sole plots.

In the second year of the experiment, main plots were 1.5 m in width and 5 m in length. Total area of a plot was 7.5 m^2. 20 Cabbage and cauliflower were planted in plots and the distance was 50 cm within rows and 75 cm between rows. 30 Lettuce plants were planted in main plots with a distance of 50 cm × 50 cm within and between rows. Onion, garlic, leek, radish, bean and peas were planted as secondery crops. Onion, garlic, leek and radish were planted between plots as two rows and beans and peas were planted as a single row. In control plots of secondary crops, onion, garlic and radish were planted with a space of 20 cm × 5 cm and beans and peas were planted 40 cm × 20 cm between and within rows, respectively.

Fertilization was done according to needs of primary crops for both years of experiment. For the control plots of secondary crops fertilizers were applied according to needs of secondary crops' requirements. N, P and K fertilizers were applied to plots in three different times. Doses were chosen according to recommendations of Vural *et al.*[13] for the vegetable crops. The experiment was set up as completely randomized block design with four replications for each treatment. Results means were separated by using Duncan's Least significant difference method.

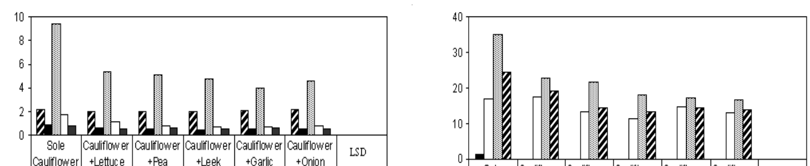
Plant nutrient analysis was performed on plant consumable parts for every species. N and P analysis were done according to Kjheldal and Barton methods, respectively. The other macro and micro element analyses were done with a Varian FS 220 atomic absorption spectrophotometer following to Güzel *et al.*[14] recommendations.

RESULTS AND DISCUSSION

Results of the first year

In the determination process of plant nutrient component in cauliflower crown, amounts of other 8 macro and micro elements except for K were found to be negligible at 5 % probability level with regard to sole cropping and intercropping. Highest amount of K was obtained at the plots where sole cauliflower cropping was made and the lowest amount was obtained from the cauliflower crowns between the row spacings of which garlic was grown. In general, it can be said that cauliflower crowns cropped solely produced more food stuff while for those grown by intercropping, intermediate crops shared in the food stuff of cauliflower (Fig. 1).

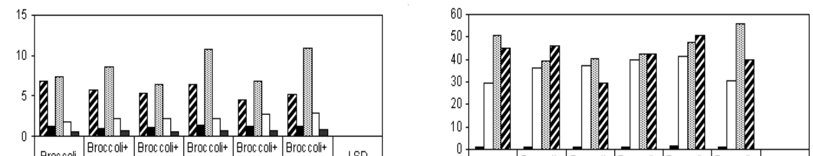
No significant effect of sole or intercropping was detected over broccoli crowns except Ca. At the parcels where sole broccoli cropping was made the lowest Ca, Mg and Mn and the highest N values were determined (Fig. 2).



	Sole Cauliflower	Cauliflower +Lettuce	Cauliflower +Pea	Cauliflower +Leek	Cauliflower +Garlic	Cauliflower +Onion	LSD
N (%)	2,223	1,963	2,020	1,993	2,113	2,137	(5%) n.s.
P (%)	0,907	0,650	0,563	0,483	0,560	0,583	(5%) n.s.
K (%)	9,440 a	5,330 ab	5,116 ab	4,700 ab	3,977 b	4,540 ab	(5%) 5,340
Ca (%)	1,766	1,127	0,777	0,710	0,760	0,833	(5%) n.s.
Mg (%)	0,803	0,563	0,647	0,566	0,613	0,573	(5%) n.s.

	Sole Cauliflower	Cauliflower +Lettuce	Cauliflower +Pea	Cauliflower +Leek	Cauliflower +Garlic	Cauliflower +Onion	LSD
Cu (ppm)	1,343	0,000	0,020	0,000	0,000	0,000	(5%) n.s.
Mn (ppm)	17,010	17,503	13,123	11,330	14,627	12,836	(5%) n.s.
Fe (ppm)	34,950	23,070	21,646	18,063	17,333	16,683	(5%) n.s.
Zn (ppm)	24,343	18,980	14,353	13,137	14,380	13,783	(5%) n.s.

Fig. 1. Mineral contents determined for cauliflower in the first year



	Broccoli	Broccoli+ Lettuce	Broccoli+ Pea	Broccoli+ Leek	Broccoli+ Garlic	Broccoli+ Onion	LSD
N (%)	6,820	5,770	5,320	6,373	4,620	5,076	(5%) n.s.
P (%)	1,287	0,973	1,077	1,383	1,243	1,233	(5%) n.s.
K (%)	7,440	8,603	6,370	10,653	6,800	10,880	(5%) n.s.
Ca (%)	1,787 b	2,097ab	2,116ab	2,077ab	2,690ab	2,923 a	(5%) 0,981
Mg (%)	0,606	0,737	0,637	0,697	0,693	0,820	(5%) n.s.

	Broccoli	Broccoli+ Lettuce	Broccoli+ Pea	Broccoli+ Leek	Broccoli+ Garlic	Broccoli+ Onion	LSD
Cu (ppm)	1,343	1,120	0,977	1,283	1,463	0,977	(5%) n.s.
Mn (ppm)	29,603	35,850	36,967	39,570	41,380	30,476	(5%) n.s.
Fe (ppm)	50,700	39,346	40,606	42,520	47,446	55,383	(5%) n.s.
Zn (ppm)	44,523	45,840	29,623	42,387	50,470	39,733	(5%) n.s.

Fig. 2. Mineral contents determined for broccoli in the first year

In the determination process of plant nutrient component in lettuce leaves, it was found that intercropping systems had an important effect on the amounts of N, P, Cu, Mn and Zn elements. Lettuce, at the parcels where its sole cropping was made and it was not in the shade of cauliflower and broccoli, lifted up more N, K, Mg and Mn from the soil. However, at the sole cropping plots, intakes of P, Ca, Cu, Fe and Zn were less (Table-1).

Cultivation of pea, either sole or between cauliflower or broccoli, did not cause any statistical effects over macro or micro element uptake at the fruits. In the research, for the pea fruits, the highest Ca (1.643 %), Mg (0.693 %) and Zn (47.030 ppm) were taken from cauliflower + pea application and the highest P (0.837 %), K (3.450 %), Cu (7.666 ppm), Mn (16.950 ppm) and Fe (54.116 ppm) were obtained from broccoli + pea application (Table-2).

According to macro and micro nutrient element analysis results carried out for leek leaves, with regard to sole cropping, intercropping did produce statistically significant effect on N and K uptake. In the study highest N (1.957 %) and Fe (58.960 ppm) were obtained from sole leek application; highest P (0.597 %), K (10.880 %), Ca (3.440%), Mg (0.680 %), Cu (4.840 ppm), Mn (29.660 ppm) and Zn (41.683 ppm) were obtained from broccoli + leek application (Table-3).

TABLE-1

AMOUNTS OF NUTRIENT ELEMENTS DETERMINED FOR SECONDARY CROP LETTUCE

	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Cu (ppm)	Mn (ppm)	Fe (ppm)	Zn (ppm)
Sole Lettuce	3.588 a	0.672 b	19.123	3.848	0.928	5.697 b	55.938 a	96.190	29.855 b
Cauliflower + Lettuce	2.097 b	0.943 ab	12.527	4.170	0.850	6.917 a	51.900 ab	140.743	60.600 a
Broccoli + Lettuce	2.260 b	1.060 a	16.087	4.593	0.900	9.723 a	42.297 b	157.39	67.813 a
LSD	(1%)0.689	(1%)0.320	(5%)n.s.	(5%)n.s.	(5%)n.s.	(1%)2.606	(5%)12.726	(5%)n.s.	(1%)28.967

TABLE-2

AMOUNTS OF NUTRIENT ELEMENTS DETERMINED FOR SECONDARY CROP PEA

	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Cu (ppm)	Mn (ppm)	Fe (ppm)	Zn (ppm)
Sole Pea	4.235	0.592	2.173	1.625	0.563	3.735	9.602	37.760	30.165
Cauliflower + Pea	3.937	0.650	2.950	1.643	0.693	6.267	16.093	52.613	47.030
Broccoli + Pea	3.383	0.837	3.450	1.603	0.683	7.666	16.950	54.116	44.520
LSD	(5%) n.s.	(5%) n.s.	(5%) n.s.	(5%) n.s.	(5%) n.s.	(5%) n.s.	(5%) n.s.	(5%) n.s.	(5%) n.s.

TABLE-3

AMOUNTS OF NUTRIENT ELEMENTS DETERMINED FOR SECONDARY CROP LEEK

	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Cu (ppm)	Mn (ppm)	Fe (ppm)	Zn (ppm)
Sole Leek	1.957 a	0.403	6.820 ab	1.845	0.652	3.033	26.918	58.960	22.080
Cauliflower + Leek	1.373 b	0.463	4.993 b	1.900	0.666	3.237	27.303	46.953	24.860
Broccoli + Leek	1.780 ab	0.597	10.880 a	3.440	0.680	4.840	29.660	49.766	41.683
LSD	(1%) 0.565	(5%) n.s.	(5%) 4.650	(5%) n.s.	(5%) n.s.	(5%) n.s.	(5%) n.s.	(5%) n.s.	(5%) n.s.

TABLE-4

AMOUNTS OF NUTRIENT ELEMENTS DETERMINED FOR SECONDARY CROP GARLIC

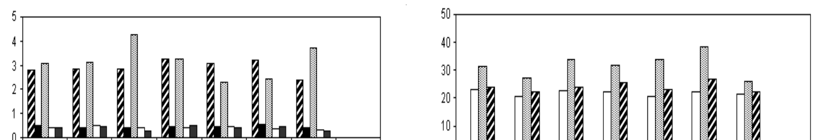
	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Cu (ppm)	Mn (ppm)	Fe (ppm)	Zn (ppm)
Sole Garlic	2.065	0.580	3.587	2.580	0.457	0.702	19.768	49.845	21.047
Cauliflower+ Garlic	2.353	0.717	4.870	2.330	0.483	0.915	27.977	40.323	23.657
Broccoli+ Garlic	3.027	0.566	4.463	2.040	0.507	0.570	29.703	47.443	17.803
LSD	(5%) n.s.	(5%) n.s.	(5%) n.s.	(5%) n.s.	(5%) n.s.	(5%) n.s.	(5%) n.s.	(5%) n.s.	(5%) n.s.

In the macro and micro nutrient element analysis carried out for garlic, no difference was detected between applications. The highest Ca (2.580 %) and Fe (49.845 ppm) amounts were obtained from sole cropping of garlic in the study (Table-4).

In the first year trial, plant nutrient element analysis were carried out only for sole onion and cauliflower + onion plots since there were not enough bulbs on the plots where onion was cultivated between broccoli (and there was no emergence in the first and third repetitions) and analysis results were presented in Table-5.

Results of the second year

It was found out that difference in 5 % statistical probability rate was negligible for sole cropping of plant nutrient component in the crown section of cauliflower, when compared to intercropping with bean, pea, radish, leek, garlic and onion. As a result of the study, Mn value (23.238 ppm) with sole cauliflower application; K value (4.258 %) with cauliflower + pea application; N value (3.267 %) with cauliflower + radish application; Ca value (0.508 %) with cauliflower + bean application; P value (0.568 %), Cu (3.930 ppm), Fe (38.453 ppm) and Zn (27.130 ppm) values with cauliflower + garlic application were found to be at highest levels (Fig. 3).

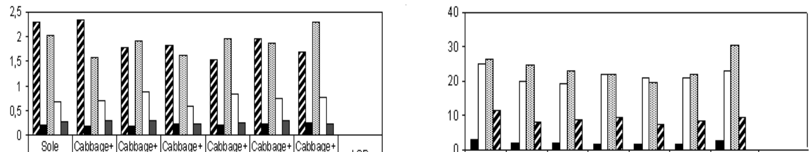


	Sole Cauliflower	Cauliflower +Bean	Cauliflower +Pea	Cauliflower +Radish	Cauliflower +Leek	Cauliflower +Garlic	Cauliflower +Onion	LSD
N (%)	2,804	2,830	2,858	3,267	3,077	3,215	2,384	(5%) n.s.
P (%)	0,541	0,432	0,420	0,495	0,467	0,568	0,455	(5%) n.s.
K (%)	3,071	3,103	4,258	3,248	2,305	2,444	3,690	(5%) n.s.
Ca (%)	0,445	0,508	0,427	0,442	0,496	0,391	0,351	(5%) n.s.
Mg (%)	0,421	0,487	0,299	0,505	0,455	0,471	0,293	(5%) n.s.

	Sole Cauliflower	Cauliflower +Bean	Cauliflower +Pea	Cauliflower +Radish	Cauliflower +Leek	Cauliflower +Garlic	Cauliflower +Onion	LSD
Cu (ppm)	3,908	3,163	3,440	3,418	3,895	3,930	2,940	(5%) n.s.
Mn (ppm)	23,238	20,613	22,398	22,275	20,518	22,043	21,490	(5%) n.s.
Fe (ppm)	31,475	27,413	33,865	31,695	33,948	38,453	26,175	(5%) n.s.
Zn (ppm)	24,048	22,070	24,110	25,540	22,988	27,130	22,273	(5%) n.s.

Fig. 3. Mineral contents determined for cauliflower in the second year

According to the analyses made on cabbage leaves, difference between applications was found to be significant at a 5 % probability rate at the uptake of N, P, K, Mg, Cu and Zn. At the end of the study, for the cabbage leaves with sole cabbage cropping, highest Cu (2.858 ppm), Mn (24.995 ppm) and Zn (11.273 ppm) values were determined; with cabbage + bean application highest N (2.326 %); with cabbage + onion application highest P (0.263 %), K (2.295 %) and Fe (30.240 ppm); with cabbage + pea application highest Ca (0.865%); and with cabbage + garlic application highest Mg (0.315%) values were determined (Fig. 4).

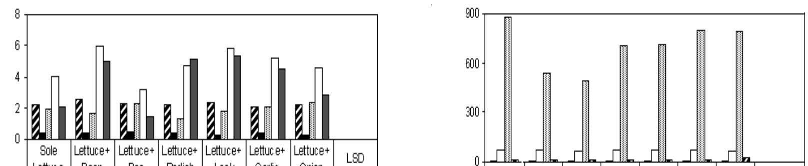


	Sole Cabbage	Cabbage+ Bean	Cabbage+ Pea	Cabbage+ Radish	Cabbage+ Leek	Cabbage+ Garlic	Cabbage+ Onion	LSD
N (%)	2,279 a	2,326 a	1,759 b	1,806 b	1,542 b	1,953 ab	1,701 b	(5%) 0,414
P (%)	0,214 b	0,196 b	0,198 b	0,236 ab	0,211 b	0,244 ab	0,263 a	(5%) 0,045
K (%)	2,037 ab	1,583 b	1,917 ab	1,630 b	1,957 ab	1,864 ab	2,295 a	(5%) 0,418
Ca (%)	0,693	0,702	0,865	0,591	0,834	0,746	0,773	(5%) n.s.
Mg (%)	0,293 ab	0,295 ab	0,313 a	0,245 b	0,254 b	0,315 a	0,241 b	(5%) 0,049

	Sole Cabbage	Cabbage +Bean	Cabbage +Pea	Cabbage +Radish	Cabbage +Leek	Cabbage +Garlic	Cabbage +Onion	LSD
Cu (ppm)	2,858 a	2,233 ab	2,013 b	1,783 b	1,928 b	1,723 b	2,405 ab	(5%) 0,617
Mn (ppm)	24,995	19,925	19,35	22,058	21,23	21,218	22,718	(5%) n.s.
Fe (ppm)	26,365	24,58	22,798	22,248	19,498	22,248	30,24	(5%) n.s.
Zn (ppm)	11,273 a	8,168 b	8,788 b	9,298 b	7,625 b	8,7 b	9,158 b	(5%) 1,733

Fig. 4. Mineral contents determined for cabbage in the second year

It was determined that as a main crop contents of K, Ca, Mg, Fe and Zn of sole lettuce cultivation was more statistically significant than intercropping at a 5 % probability rate. According to the result of analysis, for the lettuce N was determined to be between 2.074-2.569 %, P between 0.309-0.376 %, K between 1.348-2.372 %, Ca between 3.156-5.915 % and Mg between 1.503-5.338 %. Cu, Mn, Fe and Zn values varied, respectively between 4.490-6.055, 60.290-69.850, 491.150-880.910 and 14.037-27.390 ppm (Fig. 5).



	Sole Lettuce	Lettuce+ Bean	Lettuce+ Pea	Lettuce+ Radish	Lettuce+ Leek	Lettuce+ Garlic	Lettuce+ Onion	LSD
N (%)	2,233	2,569	2,287	2,238	2,371	2,074	2,198	(5%) n.s.
P (%)	0,353	0,375	0,431	0,376	0,309	0,347	0,309	(5%) n.s.
K (%)	1,911 ab	1,682 ab	2,258 a	1,348 b	1,747 ab	2,028 ab	2,372 a	(5%) 0,629
Ca (%)	4,055 bc	5,915 a	3,156 c	4,702 abc	5,798 a	5,197 ab	4,524 abc	(5%) 1,561
Mg (%)	2,087 d	4,974 ab	1,503 e	5,171 a	5,338 a	4,454 b	2,885 c	(5%) 0,540

	Sole Lettuce	Lettuce+ Bean	Lettuce+ Pea	Lettuce+ Radish	Lettuce+ Leek	Lettuce+ Garlic	Lettuce+ Onion	LSD
Cu (ppm)	4,490	6,055	5,387	5,473	5,567	5,860	5,465	(%5) n.s.
Mn (ppm)	69,850	68,665	62,770	69,270	68,903	67,933	60,290	(%5) n.s.
Fe (ppm)	880,910 a	544,700 d	491,150 e	702,275 c	710,600 c	803,780 b	791,895 b	(%5) 38,018
Zn (ppm)	14,075 b	17,155 b	17,050 b	16,530 b	17,040 b	14,037 b	27,390 a	(%5) 6,149

Fig. 5. Mineral contents determined for lettuce in the second year

According to the result of analysis carried out on intercropping of bean, difference in N content was found to be statistically significant at 5 % level while N content displayed variation between 2.545 and 3.050 % (Table-6).

It was determined that in cropping systems, amounts of K, Ca, Cu and Zn affected bean fruit at a significance level of 5 %. According to the applications for bean N displayed a variety between 3.381-3.932 %, P 0.369-0.416 %, K 0.057-0.188 %, Ca 1.203-1.863 %, Mg 6.356-6.519 %, Cu 3.543-5.590 ppm, Mn 15.820-18.538 ppm, Fe 36.970-51.830 ppm and Zn 16.230-22.408 ppm (Table-7).

TABLE-5
AMOUNTS OF NUTRIENT ELEMENTS DETERMINED FOR SECONDARY CROP ONION

	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Cu (ppm)	Mn (ppm)	Fe (ppm)	Zn (ppm)
Sole Onion	0.898	0.398	2.605	1.543	0.490	0.092	8.255	9.413	12.635
Cauliflower + Onion	1.193	0.457	3.020	1.193	0.460	0.000	8.687	11.280	14.473
Broccoli + Onion	–	–	–	–	–	–	–	–	–

TABLE-6
AMOUNTS OF NUTRIENT ELEMENTS DETERMINED FOR SECONDARY CROP BEAN

	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Cu (ppm)	Mn (ppm)	Fe (ppm)	Zn (ppm)
Sole Bean	3.050 a	0.467	3.006	0.888	0.487	11.293	65.943	74.158	31.350
Cauliflower + Bean	2.725 bc	0.425	2.663	0.761	0.471	9.998	62.855	60.700	34.625
Cabbage + Bean	2.545 c	0.426	2.484	0.904	0.507	9.303	66.11	57.513	31.475
Lettuce + Bean	2.940 ab	0.397	2.694	0.806	0.523	7.020	60.603	64.108	24.023
LSD	(5%) 0.306	(5%) n.s.	(5%) n.s.	(5%) n.s.	(5%) n.s.	(5%) n.s.	(5%) n.s.	(5%) n.s.	(5%) n.s.

TABLE-7
AMOUNTS OF NUTRIENT ELEMENTS DETERMINED FOR SECONDARY CROP PEA

	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Cu (ppm)	Mn (ppm)	Fe (ppm)	Zn (ppm)
Sole Pea	3.546	0.416	0.188 a	1.863 a	6.519	5.59 a	18.538	47.958	22.408 a
Cauliflower + Pea	3.467	0.378	0.065 b	1.534 ab	6.356	4.428 b	18.073	51.830	18.123 b
Cabbage + Pea	3.932	0.408	0.057 b	1.203 b	6.511	4.163 b	17.058	40.045	22.198 a
Lettuce + Pea	3.381	0.369	0.065 b	1.798 a	6.392	3.543 b	15.820	36.97	16.230 b
LSD	(5%) n.s.	(5%) n.s.	(5%) 0.050	(5%) 0.345	(5%) n.s.	(5%) 1.138	(5%) n.s.	(5%) n.s.	(5%) 2.753

TABLE-8
AMOUNTS OF NUTRIENT ELEMENTS DETERMINED FOR SECONDARY CROP RADISH

	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Cu (ppm)	Mn (ppm)	Fe (ppm)	Zn (ppm)
Sole Radish	2.842	0.479	1.585	0.716	0.400	3.408	23.608	76.605	27.985
Cauliflower + Radish	2.802	0.527	5.030	0.593	0.370	2.760	19.653	50.813	26.533
Cabbage + Radish	2.417	0.544	3.552	0.635	0.393	3.113	19.910	58.475	25.615
Lettuce + Radish	2.609	0.480	3.307	0.666	0.412	2.930	18.198	66.058	24.788
LSD	(5%) n.s.	(5%) n.s.	(5%) n.s.	(5%) n.s.	(5%) n.s.	(5%) n.s.	(5%) n.s.	(5%) n.s.	(5%) n.s.

In the result of analysis, it was found that nutrient element contents present in radish root was not statistically affected from intercropping system. In the study, highest N (2.842 %), Ca (0.716 %), Cu (3.408 %), Mn (23.608 ppm), Fe (76.605 ppm) and Zn (27.985 ppm) were obtained from sole radish application; highest K (5.030 %) from cauliflower + radish; highest P (0.544 %) from cabbage + radish and highest Mg (0.412 %) from lettuce + radish applications (Table-8).

For the leek, difference of nutrient element and amount of Fe and Zn with intercropping from sole cropping was found to be important at 5 % probability level. In the study, when cropping systems were considered, amounts of Fe and Zn displayed variation respectively between 431.543-717.300 ppm and 14.305-23.938 ppm (Table-9).

While the effect of N, P, K, Ca, Mg, Mn and Zn amounts on cropping systems was found to be important at 5 % probability level for garlic, effect of those on copper and iron was seen to be negligible. In the study N displayed changing between 1.257-2.182 %, P between 0.180-0.315 %, K 0.003-0.014 %, Ca between 0.222-0.331 %, Mg 6.526-6.841 %, Cu 1.460-4.740 ppm, Mn 8.195-14.527 ppm, Fe 49.378-80.078 ppm and Zn 13.068-19.003 ppm at garlic leaves (Table-10).

Effect of intercropping systems on N, K and Ca contents of onion was determined to be significant at 5 % probability level. Highest N (2.205 %), K (0.132 %), Ca (1.278 %) and Fe (72.318 ppm) amounts were obtained from sole onion cropping (Table-11).

Yildirim[3] reported that when cabbage and cauliflower were grow with other vegetables, their elemental composition remained the same or changes in amounts were negligible. N, P, K and Ca amounts did not change for broccoli when it was grown as a primary crop along with beans and cauliflower[15]. Similar results were obtained for cauliflower for N, P, K, Ca, Mg and Fe amounts when it was intercropped with beans, radish, onions and lettuce[16]. These results are in agreement with the results obtained in the present study.

According to first year results, Ca amounts in broccoli heads and K amounts in cauliflower crowns were significantly affected by intercropping. In the second year, N, P, K, Cu, Mg, Zn; and K, Ca, Mg, Fe and Zn were significantly affected by intercropping for cabbage and lettuce, respectively. In take of N, P, K of red pepper was significantly affected by intercropping which agrees with our results[17].

In general sense, in the first and second years of the study, regarding the sole croppings of cabbage, cauliflower, broccoli and lettuce and intercroppings of the intermediate crops which were used, since there was no important significant difference between nutrition rates and especially plant growth of main products did not encounter a negative condition because of

TABLE-9

AMOUNTS OF NUTRIENT ELEMENTS DETERMINED FOR SECONDARY CROP LEEK

	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Cu (ppm)	Mn (ppm)	Fe (ppm)	Zn (ppm)
Sole Leek	1.885	0.250	2.306	2.026	0.521	4.078	40.525	495.43 bc	21.280 a
Cauliflower + Leek	1.699	0.247	1.876	1.753	0.471	4.603	42.750	671.12 ab	23.938 a
Cabbage + Leek	1.509	0.206	1.388	1.605	0.467	3.355	39.015	431.543 c	16.893 b
Lettuce + Leek	1.738	0.160	1.585	2.570	0.525	2.868	42.805	717.300 a	14.305 b
LSD	(5%) n.s.	(5%) n.s.	(5%) n.s.	(5%) n.s.	(5%) n.s.	(5%) n.s.	(5%) n.s.	(5%)178.314	(5%) 4.354

TABLE-10

AMOUNTS OF NUTRIENT ELEMENTS DETERMINED FOR SECONDARY CROP GARLIC

	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Cu (ppm)	Mn (ppm)	Fe (ppm)	Zn (ppm)
Sole Garlic	1.290 b	0.180 b	0.014 a	0.331 a	6.526 b	1.903	8.195 b	49.378	13.068 b
Cauliflower + Garlic	2.182 a	0.315 a	0.003 b	0.231 b	6.614 b	4.740	14.527 a	50.903	19.003 a
Cabbage + Garlic	1.89 a	0.227 b	0.010 ab	0.222 b	6.813 a	3.525	11.383 ab	80.078	18.493 a
Lettuce + Garlic	1.257 b	0.246 b	0.004 b	0.251 b	6.841 a	1.460	10.515 ab	64.485	13.66 b
LSD	(5%) 0.583	(5%) 0.068	(5%) 0.008	(5%) 0.068	(5%) 0.175	(5%) n.s.	(5%) 4.010	(5%) n.s.	(5%) 2.360

TABLE-11

AMOUNTS OF NUTRIENT ELEMENTS DETERMINED FOR SECONDARY CROP ONION

	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Cu (ppm)	Mn (ppm)	Fe (ppm)	Zn (ppm)
Sole Onion	2.205 a	0.428	0.132 a	1.278 a	6.444	3.688	17.125	72.318	16.603
Cauliflower + Onion	1.392 b	0.460	0.082 ab	0.762 b	6.590	3.038	20.045	67.218	17.72
Cabbage + Onion	1.139 b	0.329	0.037 b	0.641 b	6.608	3.048	16.788	60.915	18.948
Lettuce + Onion	1.05 b	0.397	0.100 ab	0.889 b	6.396	4.053	14.203	47.378	17.823
LSD	(5%) 0.392	(5%) n.s.	(5%) 0.064	(5%) 0.347	(5%) n.s.	(5%) n.s.	(5%) n.s.	(5%) n.s.	(5%) n.s.

nutrition. Especially, if garlic and onion used as secondary crop, there was no negative effect on plant nutritional uptake of main crops. But in some cases, when the secondary plants were sole in the plots, due to competition, they took more mineral elements than when they are secondary crop.

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