Response of cowpea (vigna unguiculata l.) to organic and chemical fertilizer applications on grain yield and yield components

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Abstract. Grain of cowpea are used for human diet and its grain contains high protein, minerals and vitamins. Cowpea was also used as hay, silage, green forage, grain fodder for feed livestocks. The experiment was conducted under irrigated conditions in the experimental area of Field Crop Deparment, Faculty of Agriculture, Cukurova University, Balcalı, Adana, Turkiye. The growing period covered throughout 2021 and 2022. The field experiment was organized in split plots based on randomized complete blocks design with three replication. Two registered cultivars (Karagöz ve Akkız) were used as a research material. In this experiment the main plots were cultivars and sub-plots were application of fertilizer. Treatments were: control (no fertilizer), solid leonardite, liquid leonardite, basal chemical dose + solid leonardite, basal chemical dose +liquid leonardite, basal chemical fertilizer + additional N fertilizer. Basal chemical dose was application of 40 kg N ha^{-1} and 100 kg N ha^{-1} P_2O_5 (Di ammonium phosphate or DAP) before sowing as recommended chemical fertilizer. Addition chemical dose was application of 80 kg N ha^{-1} (Ammonium sulfate) over the basal dose at the seedling stage. Rhizobia inoculant was not applied during the field experiment. Akkız seed yield was significantly higher in application of liquid leonardite fertilizer and the combination of basal chemical fertilizer + liquid leonardite fertilizer with 1656 and 1533 kg ha^{-1} respectively, compared to other treatments. The grain yield in the control plot was the lowest in both cultivars. As a result, applying liquid leonardite fertilizer into the soil before sowing can be useful for grain production in cowpea.

1 Introduction

Cowpea orginated from Africa (*Vigna unguiculata* L.) is an important grain legumes cultivated crop in the hot regions worldwide and produced mostly in Africa, Asia and America.Dry cowpea has been grown on land of 14.9 million hectares area and grain yield is 602 kg ha^{-1} [1].

Green pod and grain of cowpea are used for human diet and its grain contains high protein, minerals and vitamins. Cowpea was also used as hay, silage, green forage, grain fodder for feed livestocks [2]. Cowpea is resistant to drought and high temperature and good growth in 30 ^{0}C. It can be succesfully grown for grain production under irrigated conditions in summer months as main crop or second crop after wheat harvesting in Mediterranean climate conditions. Native rhizobium population which is effective in cowpea has been not found at sufficient level in some regions. Insufficient nodule formation is observed in the root of cowpea in our region. [3] recorded that highest seed yield in cowpea was obtained from application of 120 kg N ha-1 when its seeds have not inoculated with rhizobia culture in Mediterranean climate conditions. However, chemical fertilizers have been used to achieve high yield at various crops in the worldwide, but intensive use of mineral fertilizer causes environmental and soil pollution [4]. Organic manure has relatively low concentrations of nutriens compared to chemical fertilizer and they decompose slowly and available for along period. [5]. Use of organic fertilizer was becoming widespread and increased fresh yield and yield components in bush bean, winged bean and yard long bean [6], in cowpea [7, 5], in chickpea [8]. On the other hand, combinations of chemical fertilizer + biofertilizer increased plant growth and photosynthesis activity in mung bean [4]. Leonardite that sources of humic acid for soil amendent is one of the important organic fertilizer for plant growth and its using increased in recently year [9, 10]. Leonardite is a natural organic material through the decomposition process and this organic material is considered as an oxidized form of lignite [11, 12]. [13] reported that liquid and solid form leonardite increased in vegetative growth and green bean yield. Leonardite application also increased seed yield in chickpea [14], faba bean [10]. Leonardite is soil amendment a natural organic matter which included high amount humic acid and mineral matter. Humic asit or other organic manures increase macro- microelements and activity of benefical bacteria in the soil [15, 12, 16].

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The aim of the present study was to exhibited the effect of organic fertilizer on seed yield and yield components of two cowpea cultivars.

2 Material and method

The experiment was conducted under irrigated conditions in the experimental area of Field Crop Deparment, Faculty of Agriculture, Cukurova University, Balcalı, Adana, Turkiye. The growing period covered throughout 2021 and 2022.

The texture of the research soil was sandy-loam. Meteorological values of Adana for experimental years and properties of experiment soil are given in Table 1 and Table 2, respectively.

Table 1. Meteorological Values of Adana for Experimental Years.

Parameters	Years	1	2	3	4	5
Mean Temperature (°C)	2021	23.9	25.9	30.0	30.6	27.3
	2022	22.8	26.5	29.4	29.5	30.0
Max. Temperature (°C)	2021	34.0	37.7	41.0	39.8	37.3
	2022	36.9	36.3	39.4	38.2	36.6
Min Temperature (°C)	2021	14.9	18.9	23.8	22.7	17.8
	2022	12.0	19.8	21.9	22.5	24.7
Relatively Humidity (%)	2021	64.9	67.2	68.0	64.4	58.8
	2022	61.7	72.7	66.2	71.0	67.1
Total Rainfall (mm)	2021	4.1	0.4	15.8	1.2	9.9
	2022	9.0	31.9	0.0	1.2	0.0

1. Month : May 2. Month June 3. Month : July
4. Month: August 5. Months : September

In this experiment, two registered cultivars (Karagöz and Akkız) were used as a research materials. The field experiment was organized in split plots design based on randomized complete blocks design with three replication.

The main plots were cultivars and sub-plots were fertilizer applications. Treatments were: control (unapplicated), solid form leonardite (2000 kg ha^{-1}), liquid form leonardite (20 lt ha^{-1}), basal chemical fertilizer + solid leonardite, basal chemical fertilizer +liquid leonardite, basal chemical fertilizer + additional N fertilizer. Basal chemical fertilizer was application of 40 kg N ha^{-1} and 100 kg P_2O_5 ha^{-1} (Diammonium phosphate) before sowing as recommended dose. Additional N fertilizer was application of 80 kg N ha^{-1} (Ammonium sulphate) over the basal dose at the seedling stage. No any fertilizer was applied to the control plots. Rhizobia inoculant was not applied in the experiment. Liquid form leonardite contents organic matter 10%, total humic+ fulvic acid 15%, K_2O %2, Cu 0.04 %, Mn 0.1%, Zn 0.1%, pH 8-10. Solid leonardite contents organic matter 50%, total humic+fulvic acid 50%, maximum nem 35% and P^H 5-7. The plots were sown at rows of 5 m lenght and 4 rows. The rows were spaced 45 cm apart and 10 cm plant to plant distance in row. The size of plot was 9.0 m^2 (5 m x 1.8 m). Harvested area was 4 x 0.9=3.6 m^2. The experiment was established on 31 May 2021 in the first year and 26 May 2022 in the second years. The plots were irrigated 3 times during the summer. Field emergence was recorded on 7 June 2021 and 1 June 2022. Maturating date was recorded on the 18th of September for Akkız and on the 23th of September for Karagöz in 2021 while it was recorded on the 11th of September for Akkız and on the 21th for Karagöz in 2022.

Table 2. Properties of experimental soil.

Properties	2021	2022
Clay %	31.1	28.7
Silty %	50.4	29.9
Sandy %	17.5	41.5
Texture	Silty Clay Loam	Clay Loam
pH	7.3	7.8
Salt (mmhos.cm^{-1})	0.25	0.16
Lime (%)	36.9	35.4
Organic Matter (%)	1.19	1.72
Phosphorus(mg.kg^{-1})	9.7	12.5
Potassium (mg.kg^{-1})	381	216

Data were recorded on five plants selected randomly from each plot. Plant height, first podding height, number of branches per plant, number of pods per plant, number of seeds per pod, seed weight per plant, 100-seed weight and grain yield (kg ha^{-1}) were investigated in experiment.

The data were analyzed according to split plot experiment design in the randomized blocks for combined years by using MSTAT-C computer software package. LSD (%5) multiple range tests were applied to compare differences among the means.

3 Results and discussion

The effects of cultivars and treatments of fertilizer form on plant height, of cowpea in combined years was presented in Table 3.

The plant height was significantly affected by cultivars in mean of the years. Karagöz (166.8 cm) had higher as compared to Akkız (122.5 cm) for plant height. Plant height was not affected by interaction of year x cultivar and years. Previous studies showed that plant height in the same cultivars varied between 113.0 and 133.0 [17], 101.8-120.5 [18] according to the different environmental conditions. Cultivars were significantly affected by fertilizer forms. The highest value was achieved by application of solid leonardite with 159.5 cm whereas lowest value was found in control treatments with 121.3 cm. On the other hand, interaction of cultivar x fertilizer treatments was not significant for plant height in the combined years. Results of present study is in agreement with the findings of [19] who recorded that

combination of leonardite with chemical fertilizers positively affected vegetative growth in cowpea. However, differences among the fertilizer applications except for control application and basal chemical fertilizers+liquid leonardit were not significant for this trait. Earlier studies recorded that leonardite or other organic manure application increased root, shoot, vegetative growth and plant biomass in bean [11, 13], plant height in cowpea [20, 5].

Table 3. The effects of cultivars and fertilizers treatments on plant height in combined years.

	Plant Height (cm)		
	2021	2022	Mean
Cultivars (C)			
Karagöz	158.8	174.9	166.8a
Akkız	129.0	115.9	122.5b
LSD 5%	YXC:N.S.		C:28.0
Treatments (T)			
1	121.9	120.6	121.3c
2	161.5	157.5	159.5a
3	145.2	152.3	148.8ab
4	147.6	156.9	152.2ab
5	147.6	131.6	139.6bc
6	139.6	153.8	146.7ab
Mean	143.9	145.4	144.7
LSD 5%	YXT:NS	Y:NS	T:19.0
CV %	15.9		

1: Control; 2: Solid leonardite; 3: Liquid leonardite; 4: Basal chemical fertilizers+solid leonardite; 5: Basal chemical fertilizers+liquid leonardite; 6: Basal chemical fertilizers+additional N fertilizer
Y: Year; N.S.: Non significant.

Differences among the cultivars and were significant found for first podding height in mean of the years (Table 4). The first podding of Karagöz (19.4 cm) is higher than Akkız (13.3 cm) as in plant height in mean of the years. First podding height was affected by cultivar x year interaction. The highest value was obtained from Karagöz in the second year while the lowest value obtained from Akkız in the same year. Differences among the treatments and interaction of year x treatments were not significant for first pod height. This trait was not influenced by years and interaction of cultivars x treatments. However, [21] revealed that application of humic acid increased first pod height in cowpea.

The effects of cultivars and treatments of fertilizer form on first podding height of cowpea in combined years were presented in Table 4.

Table 4. The effects of cultivars and fertilizers treatments on first podding height in combined years.

	First Podding Height (cm)		
	2021	2022	Mean
Cultivar (C)			
Karagöz	18.6ab	20.1a	19.4a
Akkız	15.4b	11.2c	13.3b
LSD 5%	YXC: 3.76		C :2.66
Treatments (T)			
1	18.7	14.7	16.7
2	17.0	15.2	16.1
3	16.6	15.9	16.3
4	14.0	18.4	16.2
5	17.6	15.5	16.5
6	17.8	14.0	15.9
Mean	16.9	15.6	16.3
LSD 5%	YXT:NS	Y:NS	T:NS
CV %	22.2		

1: Control; 2: Solid leonardite; 3: Liquid leonardite; 4: Basal chemical fertilizers+solid leonardite; 5: Basal chemical fertilizers+liquid leonardite; 6: Basal chemical fertilizers+additional N fertilizer
Y: Year; N.S.: Non significant.

The effects of cultivars and treatments of fertilizer form on branches per plant of cowpea in combined years were presented in Table 5.

Table 5. The effects of cultivars and fertilizers treatments on branches per plant in combined years.

	Branches per plant		
	2021	2022	Mean
Cultivars (C)			
Karagöz	4.3b	7.7a	5.9
Akkız	5.1b	7.1a	6.1
LSD 5%	YXC: 1.1		N.S.
Treatments (T)			
1	4.2	7.1	5.6
2	5.4	7.6	6.5
3	4.5	6.5	5.5
4	5.2	7.8	6.5
5	4.9	7.3	6.1
6	3.9	7.9	5.9
Mean	4.7B	7.4A	6.0
LSD 5%	YXT:NS	Y:0.75	T:NS
CV %	16.3		

1: Control; 2: Solid leonardite; 3: Liquid leonardite; 4: Basal chemical fertilizers+solid leonardite; 5: Basal chemical fertilizers+liquid leonardite; 6: Basal chemical fertilizers+additional N fertilizer
Y: Year; N.S.: Non significant.

Branches per plant were not significantly affected by cultivars and cultivar x treatment interaction in combined years (Table 5). Interaction between year x cultivar was significant for main branches per plant. The highest branches per plant value was obtained from Karagöz (7.7

cm) in the second experiment year while the lowest value was obtained from Karagöz (4.3 cm) in the first experiment year. [22] reported that branches number found between 3.6 and 4.4 in cowpea. Differences among the treatments and treatment x year interaction were not significant for this trait. These results exhibite that solid leonardite and some organic fertilizer treatments can be not utilized by plant in the short term because of decompose slowly in the soil [5, 16]. The number of branches per plant was statistical higher in 2022 (7.4) than 2021 (4.7). Similarly to our study, [15] reported application of organic fertilizer did not affect branches per plant in mung bean. [23] recorded that varied between 8.0-10.8 according to organic fertilize treatments in mung bean. However, contrary to our finding, [24] reported that fertilizer+ humic acid increased branches per plant.

Table 6. The effects of cultivars and fertilizer treatments on pods per plant in combined years.

	Pods Per Plant		
	2021	2022	Mean
Cultivars (C)			
Karagöz	11.4	13.0	12.2b
Akkız	19.2	22.5	20.9a
LSD 5%	YXC: N.S.		C:5.31
Treatments (T)			
1	10.5f	15.4cde	12.9d
2	17.2bcd	15.0cde	16.1bc
3	17.8bc	14.4de	16.1bc
4	16.3bcd	19.0b	17.7b
5	17.3bcd	24.8a	21.0a
6	12.8ef	18.0bc	15.4c
Mean	15.3	17.8	16.5
LSD 5%	YXT:3.06	Y:NS	T:2.16
CV %	15.9		

1: Control; 2: Solid leonardite; 3: Liquid leonardite; 4: Basal chemical fertilizers+solid leonardite; 5: Basal chemical fertilizers+liquid leonardite; 6: Basal chemical fertilizers+additional N fertilizer
Y: Year; N.S.: Non significant.

The effects of cultivars and fertilizer treatments on pods per plant in combined analysis were given in Table 6. Combined years revealed that pods per plant was significantly affected by cultivars, but not years. Akkız (20.9) had higher pods per plant compared to Karagöz (12.2). Previous study reported that pods per plant varied between 25.7 and 49.0 [25], 9.05 and 10.90 [26], 16.3 and 35.8 [27] in different cowpea genotypes. Yield parameters can be affected by ecological conditions and cultivars [25]. Pods per plant was not influenced by interaction of year x cultivar, but fertilizer treatment x year was significant. The highest pods per plant were found in the application of basal chemical fertilizer + liquid leonardite in the second year (24.8) whereas the lowest one had control application (unapplicated fertilizer) in the first year (10.5). There were significant differences among the treatments in mean of the years. The pods per plant ranged between 12.9 and 21.0. The pods per plant obtained in basal chemical fertilizer + liquid leonardite were significantly higher than other fertilizer applications. The minimum value was observed in control application. There was no interaction between cultivar and treatment. Previous studies reported indicated that humic acid increased pods per plant in cowpea [20, 21]. [16] reported that leonardite application affected positively pods per plant compared to control and chemical fertilizer in cowpea.

The effects of cultivars and fertilizer treatments on seeds per pod in combined analysis were given in Table 7. Fertilizer treatments and cultivars had insignificant effect on the number of seeds per pod (Table 7). However, seeds per pod varied from 6.19 to 6.59 in the various fertilizer forms. Year x cultivar, year x treatment and cultivar x treatment interaction was also no significant for this trait. Seeds per pod was affected by years and it was significantly higher in the second year (7.20) compared to the first year (5.59). In contrary to our findings, [21] reported that humic acid increased seeds per pod in cowpea.

Table 7. The effects of cultivars and fertilizer treatments on seeds per pod in combined years.

	Seeds Per Pod		
	2021	2022	Mean
Cultivars (C)			
Karagöz	5.41	7.04	6.23
Akkız	5.78	7.37	6.57
LSD 5%	YXC: N.S.		N.S.
Treatments (T)			
1	5.40	6.97	6.19
2	5.80	7.00	6.40
3	5.82	7.11	6.46
4	5.48	7.44	6.46
5	5.93	7.25	6.59
6	5.15	7.45	6.30
Mean	5.59B	7.20A	6.40
LSD 5%	YXT:NS	Y:0.55	T:NS
CV %	15.0		

1: Control; 2: Solid leonardite; 3: Liquid leonardite; 4: Basal chemical fertilizers+solid leonardite; 5: Basal chemical fertilizers+liquid leonardite; 6: Basal chemical fertilizers+additional N fertilizer
Y: Year; N.S.: Non significant.

Significant differences among the cultivars were no observed in the seed weight per plant in the mean of the years (Table 8). Interaction of cultivar x year was also no significant for this trait. Seed weight per plant was influenced by treatments. The highest value was obtained in the application of basal chemical fertilizer + liquid leonardite with 14.7 g whereas the minimum value was found in control application with 9.71 g as in pods per plant in mean of the years. Year x treatment interaction was significant and the highest value was obtained from application of basal chemical fertilizer +liquid leonardite with 17.5 g in 2022 whereas the lowest one was observed in control application with 7.58 g in 2021. Differences among the fertilizer treatments except for control application and basal fertilizer+additional N fertilizer

were not significant in the first year. Seed weight per plant was significantly higher in the second year (14.2 g) than the first year (10.9 g). Interaction of cultivar x fertilizer was significant for seed weight per plant (Table 11). The highest seed weight per plant was obtained from application of basal chemical fertilizer + liquid leonardite in Akkız with 15.6 g and followed basal chemical fertilizer + solid leonardite in Akkız with 14.6 g. The lowest value was observed in control application in Karagöz and Akkız with 8.7 and 10.7 g respectively. [20] reported that increasing level of humic acid increased seed plant weight in cowpea

The effects of cultivars and fertilizer treatments on seed weight per plant in combined analysis were given in Table 8.

Table 8. The effects of cultivars and fertilizer treatments on seed weight per plant in combined years.

	Seed Weight Per Plant (g)		
	2021	2022	Mean
Cultivars (C)			
Karagöz	10.7	13.2	11.9
Akkız	11.2	15.2	13.2
LSD 5%	YXC: N.S.		N.S.
Treatments (T)			
1	7.58e	11.8c	9.71c
2	12.6bc	12.9bc	12.7b
3	13.0bc	14.5b	13.7ab
4	11.4cd	13.7bc	12.5b
5	11.9c	17.5a	14.7a
6	9.08de	14.9b	12.0b
Mean	10.9B	14.2A	12.6
LSD 5%	YXT:2.49	Y:2.53	T:1.76
CV %	17.0		

1: Control; 2: Solid leonardite; 3: Liquid leonardite; 4: Basal chemical fertilizers+solid leonardite; 5: Basal chemical fertilizers+liquid leonardite; 6: Basal chemical fertilizers+additional N fertilizer
Y: Year; N.S.: Non significant.

The effects of cultivars and fertilizer treatments on the 100 seed weight were presented in Table 9. 100 seed weight was affected by cultivars in mean of the years. 100- seed weight of Karagöz (22.8 g) was greater than Akkız (14.8 g). Year x cultivar interaction was also significant for this trait. The highest 100 seed weight was achieved by Karagöz with 24.8 g in 2021 while the lowest value was Akkız with 13.8 g in 2022**.** Previous studies reported that 100 seed weight varied between 12.0 and 25.0 g [28] 9.3 and 25.4 g [27] in various cowpea genotypes. Effects of treatments on 100-seed weight were not significant in mean of the years. Influence of year x treatment interaction on the 100 seed weight was significant. The highest value was found in the application of basal chemical fertilizer + additional N fertilizer with 21.0 g and basal chemical fertilizer + liquid leonardite with 20.9 g in 2021 while the lowest value was obtained in application of basal chemical fertilizer+liquid leonardite with 16.3 g in 2022. Effects of years and cultivar x fertilizer interaction on 100 seed weight were not significant for this trait.

[14] indicated that leonardite application of 1000 kg ha^{-1} increased 100 seed weight in chickpea. [5] reported that organic fertilizer affected 1000 seed weight positively in the second year, but not first year in cowpea.

Table 9. The effects of cultivars and fertilizer treatments on 100 seed weight in combined years.

	100-Seed Weight (g)		
	2021	2022	Mean
Cultivars (C)			
Karagöz	24.8a	20.8b	22.8a
Akkız	15.9c	13.8d	14.8b
LSD 5%	YXC: 1.29		C:0.91
Treatments (T)			
1	19.8ab	17.7cd	18.7
2	19.4b	17.5cd	18.4
3	20.9a	17.4cd	19.1
4	20.4ab	17.9c	19.1
5	20.9a	16.3d	18.6
6	21.0a	17.0cd	19.0
Mean	20.4	17.3	18.8
LSD 5%	YXT:1.38	Y:0.91	T: N.S.
CV %	6.3		

1: Control; 2: Solid leonardite; 3: Liquid leonardite; 4: Basal chemical fertilizers+solid leonardite; 5: Basal chemical fertilizers+liquid leonardite; 6: Basal chemical fertilizers+additional N fertilizer
Y: Year; N.S.: Non significant.

The effects of cultivars and fertilizer treatments on the grain yield were presented in Table 10. Significant differences among the cultivars were found for grain yield in mean of the years. Grain yield was significantly greater in Akkız (1420 kg ha^{-1}) than Karagöz (1058 kg ha^{-1}). Effect of interaction of year x cultivar on the grain yield was not significant. Previous studies exhibited that grain yield varied between 1124-1335 kg ha^{-1} [29] and 1560-2386 kg ha^{-1} [18],1010-1420 kg ha^{-1}[22] according to the cultivars and environmental conditions. Grain yield was also significantly affected by fertilizer treatments in mean of the years. Grain yield obtained from application of basal chemical fertilizer +liquid leonardite with 1548 kg ha^{-1} was significantly higher than other treatments. The lowest value was found in control application with 1046 kg ha^{-1}.

Table 10. The Effects of cultivars and fertilizer treatments on grain yield in combined years.

	Grain Yield (kg ha^{-1})		
	2021	2022	Mean
Cultivars (C)			
Karagöz	1035	1080	1058b
Akkız	1402	1437	1420a
LSD 5%	YXC: N.S.		C: 125.2
Treatments (T)			
1	1090	1003	1046c
2	1187	1175	1181c
3	1341	1428	1385b
4	1133	1225	1179c
5	1457	1637	1548a
6	1103	1084	1093c
Mean	1219	1259	1239
LSD 5%	YXT:N.S	Y: N.S.	T:149.7
CV %	14.7		

1: Control; 2: Solid leonardite; 3: Liquid leonardite; 4: Basal chemical fertilizers+solid leonardite; 5: Basal chemical fertilizers+liquid leonardite; 6: Basal chemical fertilizers+additional N fertilizer
Y: Year; N.S.: Non significant.

Statistical analysis exhibited a significant of cultivar x fertilizer interaction for seed yield in the combined years (Table 11). Seed yields of Akkız in application of liquid leonardite (1656 kg ha^{-1}) and basal chemical fertilizer+ liquid leonardite (1533 kg ha^{-1}) were significantly higher than other applications. This finding shown that liquid leonardite provided a good environment conditions such as water holding capacity, plant nutrients uptake from soil and activity of microorganism for plant growth compared to chemical fertilizer and solid leonardite. Similar opinion was reported in vermicompost and other organic fertilizer application by [16, 12, 15].

Table 11. Interaction of cultivars and fertilizer treatments for some traits in combined years.

Treatments	Cultivar			
	Seed Weight Per Plant(g)		Grain Yield (kg ha^{-1})	
	Karagöz	Akkız	Karagöz	Akkız
1	8.72e	10.7de	885.0g	1208de
2	13.8abc	11.6cd	920.9fg	1441bc
3	13.6abc	13.8abc	1113ef	1656a
4	10.5de	14.6ab	960.7fg	1398bcd
5	13.8abc	15.6a	1562ab	1533ab
6	11.1de	12.9bcd	903.8fg	1283cde
LSD 5%	2.49		212	

1: Control; 2: Solid leonardite; 3: Liquid leonardite; 4: Basal chemical fertilizers+solid leonardite; 5: Basal chemical fertilizers+liquid leonardite; 6: Basal chemical fertilizers+additional N fertilizer
Y: Year; N.S.: Non significant.

This results exhibited that useful of liquid leonardite in the short term can be more than solid leonardite. Some organic manure or leonardite decomposes slowly and available for along period [5, 16]. Control application (unapplicated fertilizer) produced the lowest grain yield in both of the cultivars. [9] revealed that marketable bean yield was higher in leonardite application compared to recommended fertilizer doses [30] reported that mineral fertilizer + leonardite application increased soil N content and garlic yield. Similar to our results, earlier studies reported that leonardite or humic acid and other manure applications increased seed yield of chickpea, faba bean, lentil and cowpea [21, 5,14, 10, 31].

4 Conclusion

Karagöz had higher plant height, first pod height,100 seed weight and lower pods per plant and seed yield compared to Akkız in mean of the years. However, there were no significant differences among the cultivars for main branches per plant, seeds per pod, seed weight per plant. According to mean of the years, combination basal chemical fertilizer with liquid leonardite had greater effect on the pods per plant, the seed weight per plant and the seed yield. Effect of fertilizer forms on the seed weight per plant, grain yield varied according to cultivars, but not other traits. The greater seed weight per plant was provided by basal chemical fertilizer + liquid leonardite in the Akkız. Akkız produced the highest seed yield in the application of liquid leonardite. As a result, liquid leonardite application into the soil before sowing can be available for high grain yield in cowpea.

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