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Investigating the interactive effect of humic acid and different levels of potassium fertilizer on yield components of cowpea

Sahar Motaghi*, Tayeb Saki Nejad, Mani Mojadam

Department of Agronomy,Ahwaz.Branch,Islamic Azad University, Ahwaz,Iran

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Key words: Cowpea, potassium fertilizer, humic acid, yield.

Abstract

In order to investigate the interactive effect of humic acid and different levels of potassium fertilizer on yield components of cowpea, a split plot experiment as randomized complete block design with four replications was carried out in Shahid Salemi Field in Ahvaz in 2011-2012. The experiment included studied factors involving three levels of potassium fertilizer (0, 200, 300 kg/ha) and three levels of humic acid fertilizer (0, 50, 100 ppm). Potassium fertilizer was applied before sowing and humic acid was used before flowering stage. The results of the research showed that the main effect of different levels of potassium fertilizer and humic acid on biological yield, harvest index, 100-grain weight, number of pods per plant, number of grains, and weight of pod was statistically significant at 1% level. Comparison of means via Duncan's test showed that the highest grain yield by 279.06 kg/ha was obtained through the use of 300 kg/ha potassium fertilizer. Moreover, the application of 200 and 300 kg/ha potassium fertilizer significantly increased the number of pods per plant in comparison to lack of its application. However, there was no significant difference between the two levels. The obtained results indicate that it is possible to increase crops yield through the application of humic acid and potassium fertilizer.

*Corresponding Author: Sahar motaghi ✉ motaghi.sahar@yahoo.com

Introduction

Iran has devoted 1 million hectares of legumes cultivation to itself and thus its problem related to the rate of yield per area unit is much lower than other countries. Daily increase of human need to nutrients on one hand, and limited production resources especially farming land on the other hand, had made the researchers think that the only way to reach agricultural self-sufficiency is to increase yield in area unit (Azizi,1998).

Humic acid is extracted from different sources such as soil, Humus, peat, oxidized lignite, coal, etc. Humic acid can directly have positive effects on plant growth. Moreover, it increases potassium, calcium, magnesium, and phosphor absorption by plant. Albasioni *et al.* (El- Bassiony *et al.,* 2010) concluded that as humic acid increased, vegetative growth and quality and grain yield improved. Naderi *et al.* concluded that humic acid spray increased grain yield 7 to 8% in comparison to control treatment(Naderi *etal.,* 2010). Humic acid application can help maintain soil iron in a form which can be absorbed and metabolized. This phenomenon is effective in alkaline and calcareous soils where there is usually shortage of iron and organic materials. Humic acid improves soil structure, increases the roots, maintains more water in soil, and helps useful bacteria grow in soil. Humic acid is compatible with the nature and does not harm plants or environment (Kouchaki and BanayanAval ,2007).These factors improve cowpea's yield. Potassium as one of the macronutrients is very important; although potassium is not a part of plant structure, it has a key role in internal reactions of plants so that it is called quality element. The major role of potassium is activating a lot of enzymes in plants which act as catalysts for making materials such as starch and protein. Potassium also plays a role in photosynthesis, osmotic adjustment, cell growth, stomatal regulation, plant's water system, loading hydrocarbons which are made in leaves onto phloem and transporting them in plant, cation - anion balance and as a cation involved in nitrogen transfer (Mahler *et al.,*1985). made use of different levels of potassium in three cultivars of soybean and concluded that the highest potassium concentration which was used significantly increased leaf area and increased the yield 2.5 % (Peaslee *et al.,*1985) The results of the research by Hatami *et al.* showed that the use of potassium fertilizer increased 100-grain weight.(Hatami *et al.,* 2010). In their research on cowpea, Geetha and Varughese observed that within the presence of potassium the number of pods per plant increased 8% in comparison to the treatment without potassium.(Geethv and varughese, 2001).

The aim of this study was to evaluate the effect of foliar Humic acid and potassium levels on yield and Yield Components of cowpea plants..

Materials and methods

This research was conducted in Shahid Salemi Field in Ahvaz in a land with an area of 1000 m^2 in 2011-2012. Ahvaz is located in southwest Khuzestan and is considered as an arid and semiarid area. The research was done as a split plot experiment in the form of randomized complete block design with 4 replications. The experiment included 36 plots, each plot contained three main plots and each main plot contained three sub plots. The space between main plots was 2.5 m and between sub plots was 2 m. the first and the last two lines were considered as margin effects. The experiment studied factors included three levels of potassium fertilizer (0, 200, 300 kg/h) and three levels of humic acid fertilizer (0, 50, 100 ppm) as foliar spray. Potassium fertilizer was added to designed treatments of plots before sowing and humic acid was applied before flowering stage.

The applied cultivar was the local cowpea of Khuzestan. The studied traits included 100-grain weight, number of pods per plant, number of grains per pod, biological yield, grain yield, and harvest index.

Determining grain yield and its components

Number of pods per plant

In order to measure the traits, 10 plants were randomly selected from each experimental unit and after counting all pods of each plant their mean was recorded as the number of pods per plant.

Number of grains per pod

In order to measure this trait 10 plants in each sample were randomly selected and after counting the number of grains per pod was measured after the counting.

100-grain weight

4 samples of harvested seeds of each plot were randomly selected each one including 25 grains and were weighed by digital scale and then their mean was recorded.

Biological yield

The sample of 1 m^2 of each experimental plot was harvested and after drying the harvested plants by the oven, all plants were weighed in order to determine biological yield.

Grain yield

The sample of 1 m^2 of each experimental plot was harvested and after separating grains from straw, the total grain yield was calculated based on kg/ha.

Harvest index

Harvest index was calculated through the ratio of grain yield to biological yield (Sayadi, 2010).

Statistical calculations

SAS software was used to analyze the variance and Duncan's test was used to compare the means and EXCEL software was used to draw diagrams and curves (MousaviJangali *et al.,* 2005).

Results and discussion

Number of pods per plant

The ANOVA results showed that the number of pods per plant was significantly affected by potassium and humic acid while the interactive effect of potassium and humic acid on the number of pods per plant was not significant (Table 1).

Table 1. The ANOVA results of the effect of different levels of potassium fertilizer and humic acid on the number of main branches, number of pods and 100-grain weight in cowpea.

Mean of squares			Variation sources
100-grain weight	Number of pods	Degree of freedom	
1185.48^{**}	101.44^{**}	2	Potassium
94.27	4.37	9	Error A
1110.82^{**}	75.14^{**}	2	Humic
204.36^{**}	8.49^{ns}	4	Potassium x Humic
29.01	3.74	18	Error B
17.13	12.64		Coefficient of Variations (CV%)

ns , *, ** repectively indicate non-significant difference and significant difference at 5% and 1% levels.

Table 2. The mean comparison of simple effects of different levels of potassium fertilizer and humic acid on number of main branches, number of pods and 100-grain weith in cowpea.

Traits mean		Treatments
100-grain weight (g)	Number of pods	Potassium
25.92 c	12.17 c	0
43.48 a	17.92 a	200
38.94 b	15.79 b	300
		Humic
22.52 ca	13.25 c	0
39.69 b	14.54 b	50
46.12 a	18.08 a	100

The means of treatments with similar letters are not significantly different from each other according to Duncan's test at 5% level.

Comparison of the means through Duncan's test showed that the highest number of pods per plant belonged to the treatment with 200 kg/ha potassium by 17.92 and the lowest number of pods belonged to control treatment. Comparison of the means through Duncan's test also showed that the highest number of pod per plant belonged to the H100 treatment by 18.8 and the lowest number of pods belonged to H0 by 13.25 (Table 2).

Table 3. The mean comparison of interactive effects of potassium and humic acid fertilizers on number of main branches, number of pods, and weight of 100-grain in cowpea.

Traits mean		Treatments	
100-grain weight (g)	Number of pods	Humic	Potassium
20.18 e	11.75 ef	0	0
27.26 cd	10.62 f	50	
30.31 c	14.12 cde	100	
24.18 d	15.75 bc	0	200
47.69 ab	17.76 ab	50	
58.57 a	20.25 a	100	
23.21 d	12.25 def	0	300
44.12 b	15.25 bcd	50	
49.49 ab	19.87 a	100	

The means of treatments with similar letters are not significantly different from each other according to Duncan's test at 5% level.

The interactive effect of potassium and humic acid on the number of pods per plant was not significantly different in treatment with 200 and 300 kg/ha potassium; however, the number of pods significantly increased in them in comparison to lack of potassium although the difference between two levels of potassium (200 and 300 kg/ha) was not significant (Table 3).

Table 4. The ANOVA results of the effect of different levels of potassium and humic acid on biological yield, grain yield and harvest index in cowpea.

Mean of squares				Sources of variations
Harvest index	Grain yield	Biological yield	Degree of freedom	
546.50**	1302.83**	1442.64**	2	Potassium
21.42	35.12	40.04	9	Error (A)
254.01**	925.32**	1272.12**	2	Humic
81.17**	1110.17*	255.46**	4	Potassium x humic
6.66	125.87	48.23	18	Error (B)
5.32	3.59	1.09		CV

ns , *, ** respectively indicate non-significant difference and significant difference at 5% and 1% levels.

Humic acid has increased the yield due to having necessary nutrients which prevents flowers loss. Since in legumes flowers loss is one of the factors restricting the yield, high doses of humic acid prevents the loss of flowers (Haghighi *et al.,* 2011). Among the yield components the number of pods per plant is one of the most important components and also the most variable component of grain yield. Number of grains per plant depends on genetic and environmental factors which will cause a lot of changes in this component of grain yield. The results obtained in this part are consistent with the findings of (Haghighi *et al.,* 2011).

in a research on cowpeas observed that in presence of potassium number of pods per plant increased 8% compared with lack of potassium (Gohari *et al.,* 2010).The increasing number of pods due to application of potassium was formerly reported by Azizy (1998) , Hatami (2010).

Table 5. The mean comparison of simple effects of different levels of potassium fertilizer and humic acid on biological yield, grain yield, and harvest index in cowpea.

Traits mean			Treatments
Harvest index (%)	Grain yield (kg)	Biological yield (kg)	Potassium
33.66 c	229.22 b	681.04 b	0
37.84 b	276.55 ab	730.75 a	200
38.74 a	279.06 a	720.36 a	300
			Humic
34.96 c	241.80 b	691.61 b	0
37.28 b	259.47 ab	696.02 b	50
38.14 a	283.94 a	744.55 a	100

The means of treatments with similar letters are not significantly different from each other according to Duncan's test at 5% level.

Lack of potassium in plant leads to early loss of leaves and this trend gets faster during the grain filling stage which leads to leaves' getting yellow and plant premature aging. This phenomenon due to problems in assimilates mobilization onto filling grain will reduce the weight of grain. Unfilled pods or incomplete filling of pods are other consequences of potassium deficit. Potassium ion plays an important role in mobilizing carbohydrates into plat organs.

It seems like that if the amount of k+ is high in plant, ATP production which is necessary for loading phloem with assimilates will increase (Hatami *et al.,* 2010).

Table 6. the mean comparison of interactive effects of different levels of potassium fertilizer and humic acid on biological yield, grain yield, and harvest index in cowpea.

Traits mean		Treatment		
Harvest index (%)	Grain yield (kg)	biological yield (kg)	Humic acid	Potassium
34.48 c	211.76 d	614.11 d	0	0
35.62 c	230.61 cd	647.50 d	50	
37.41 bc	247.44 bc	661.48 cd	100	
36.56 bc	248.66 bc	680.12 c	0	200
37.80 b	268.46 b	710.18 bc	50	
39.22 c	290.54 a	740.78 a	100	
37.59 b	263.43 b	700.71 bc	0	300
38.66 cb	282.33 ab	730.25 b	50	
39.38 a	291.43 a	740.09 a	100	

The means of treatments with similar letters are not significantly different from each other according to Duncan's test at 5% level.

100-grain weight

Another important components of grain yield is the weight of 100-grain. Its variety is strongly influenced by genetic factors, but its amount is influence by maturity stage conditions, as well (Kouchaki *et al.,* 2007).

The ANOVA and statistical results of the effects of treatments on average weight of 100-grain are shown in Table (1). In this Table it is observed that the effect of potassium and humic acid and the interactive effect of potassium and humic acid fertilizers on the average weight of 100-grain was significant.

The ANOVA results of the effect of potassium on weight of 100-grain which are displayed in Table (2) indicated that the highest weight of 100-grain belonged to the treatment with 200 kg/ha potassium by 43.48 and the lowest amount belonged to control treatment (without humic acid).

The ANOVA results of the effect of humic acid on weight of 100-grain which are displayed in (Table 2) indicated that the highest weight of 100-grain belonged to the treatment with 100ppm humic acid and the lowest weight belonged to the control treatment (without humic acid).

The interactive effects of potassium fertilizer and humic acid showed that the highest weigh of 100-grain belonged to the treatment by 200 kg/ha potassium and 100 ppm humic acid and the lowest weight belonged to the control treatment (without application of potassium and humic acid).

Humic acid increases 100-grain weight by effective mobilization of assimilates from leaves into grains. When the plant is strongly growing, photosynthetic materials transfer into the roots. When the roots develop the condition for absorbing nutrients is provided which in turn increases photosynthesis. When the plant reaches maturity stage, it transfers assimilates to reproductive organs. Humic acid fertilizer increases 100-graain weight by boosting and improving this action (Haghighi *et al.,* 2011).

These results were consistent with the findings of Sabzevari and Khazaei (2009) and Sayadi (2010) and Yulkan (2008).

The results of the research by Hatami *et al.,* (2010) , Gohari *et al.,* (2010) showed that the use of potassium fertilizer increases the weight of 100-grain.

Biological yield

According to ANOVA results, the effect of different levels of potassim fertilizer and also different levels of humic acid and the interactive effect of them on biological yield were significant at 1% level (Table 4). The table showed that there was not a significant difference between treatments with 200 and 300 kg/ha potassium, but they significantly increased biological yield in comparison to the treatment without potassium application.

Motalebi *et al.,* (2000), Gohari *et al.,* (2010) concluded that potassium would increase biological yield.

As the levels of humic acid increased, bilogical yield increased, too. But there was not a significant difference between H50 and H0 treatments. The highest and the lowest mean of biological yield respectively belonged to H100 and H0 (control) treatments by 744.55 and 691.61 (kg/ha) (Table 4).

By increasing the content of plant nitrogen, humic acid will cause the increase of growth, height, and consequently biological yield (Ghorbani *et al.,* 2010). In a study, the application of humic acid in nutrient solution increased the content of nitrogen in shoots and also increased the growth of shoots and root in corn. (Tan and Tantiwiramanond,1982). The results were consistent with the findings of Vaughan and Linehan,(2004) , Valderini (1996).

Examining the interactive effect of potassium and humic acid showed that the highest biological yield by 740.78 g/m^2 belonged to the treatment with 200 kg/ha K and 100 ppm H which was not significantly different from the treatment with 300 kg/ha p and 100 ppm H, and the g/m² belonged to control treatment.

Grain Yield

According to ANOVA results, different levels of potassium fertilizer and humic acid had a significant effect on biological yield at 1% level while the interactive effect of potassium and humic acid was significant at 5% level.

Comparison of the means via Duncan's test showed that there was a significant difference between potassium treatments. The highest grain yield by 279.06 g/m² belonged to K300 treatment and the lowest grain yield by 229.22 g/m² belonged to control treatment.

Potassium as an anions carrier transfers them from the root to the leaves and is also used as catalyst for many materials. Therefore, its shortage will decrease nitrogen absorption from soil and protein production via absorbed nitrogen sources in plant. Similarly, as it intensifies carbon capture and regulates pressure inside the cell and water storage in plant, its shortage will cause disorder in respiratory system, pressure inside the cell, and water storage in plant which finally results in the reduction of protein, sugar, and starch production, potassium fertilizer application can act as a complement for nitrogen fertilizers in increasing the grain yield (Hatami *et al.,* 2010). As humic acid levels increased, grain yield increased, too.

Comparison of the means via Duncan's test showed that the highest grain yield by 291.43 g/m² belonged to the treatment with H100 and K300 which was not significantly different from the treatment with H100 and K200 and the lowest grain yield by 211.76 g/m² belonged to the control treatment (without application of humic and potassium).

Naderi *et al.,* (2000). in a study found that humic substances spray at development stage of wheat, increased the grain yield 7 to 8% compared to control treatment. Ghorbani *et al.,* (2010). concluded that acid humic caused the persistence of photosynthetic issues and thus increased the grain yield. The above results are consistent with the findings of Turkmen *et al.,* (2004) , Haghighi *et al.,* (2011) , Sharif *et al.,* (2002).

Harvest Index

The ANOVA results showed that the effect of potassium fertilizer and humic acid and their interactive effect on harvest index were significant at 1% level (Table 4).

The mean comparison of potassium fertilizer showed that the treatment with 300 kg/ha potassium had the highest percentage of harvest index by 38.47% and control treatment had the lowest percentage by 33.66 %.

The mean comparison of humic acid showed that the treatment with 100 ppm humic acid had the highest percentage by 38.11% and control treatment had the lowest percentage by 34.96 %.

The results of the interactive effects of potassium fertilizer and humic acid on harvest index showed that the treatment with 300 kg/ha potassium and 100 ppm humic acid had the highest percentage of harvest index by 39.38%, but it was not significantly different from the treatment with 200 kg/ha potassium and 10 ppm humic acid.

Harvest index is a ratio of biological yield which forms economic performance, and through the increasing share of dry matter for economic performance, the harvest index increases too. Gohari *et al.,* (2010). concluded that potassium application increased the harvest index of cowpea which is consistent with obtained results. Haghighi *et al.,* (2011). examined the effect of humic acid on growth parameters of broad bean and their results were consistent with above results.

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