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Study of Source and Different Levels of Potassium Fertilizer on Canola (*Brassica napus* L.) Production

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ABSTRACT

Increasing the area of arable oilseed land, particularly rapeseed, and the important role of potassium in yield and oil content, especially in calcareous and high pH soils, need to more knowledge about plant nutrition requirement. In this study, the effect of sources and different levels of potassium fertilizers on some quality and quantity characteristics on canola yield were assessed by combined analysis factorial experiment based on randomized complete blocks design during 2011-2013. Two potassium fertilizer sources: potassium sulfate and potassium chloride with four levels of potassium fertilizer control, 100, 150, 200 $kg.ha^{-1}$ in main plot and sub plot, respectively. Results of combined analysis of variance showed effect of potassium sources on capsule in plant and oil yield was significant at 5% probability level. Also effect of potassium rate on capsule in plant, seed yield and oil content was significant at 5% and 1% probability level. Interaction effect of treatments on capsule in plant, seed yield, oil yield and oil content was significant. Potassium chloride fertilizer impact on yield and its components showed better results. Interaction effects of sources and rates of potassium showed the highest seed and oil yield (2128 and 878 $kg.ha^{-1}$, respectively) from 100 $kg.ha^{-1}$ potassium chloride treatment. Also the highest capsule in plant and seed in capsule obtained from 150 $kg.ha^{-1}$ potassium chloride treatment. Finally, for increasing canola yield application of 100 $kg.ha^{-1}$ potassium chloride recommended.

Keywords*:* *Macro element, Oil, Rapeseed, Yield.*

INTRODUCTION

Canola is a member of the mustard family grown for the production of animal feed and vegetable oil for human consumption. Canola oil has the lowest levels of saturated fat compared to some other vegetable oils. Although canola is a summer crop in the temperate and cool areas of the world, it is mainly grown in south west of Iran as a winter crop in rotation with rice and corn (Aminpanah, 2013). Management of balanced fertilizer application according to plant growth requirements and soil testing is one of the strategies for improving the quality and quantity of agricultural products (Singh *et al*., 2015).

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Therefore, consideration of oil testing and application of elements required by plants are important strategies for increasing production of agricultural products (Pervez *et al*., 2004). Macro fertilizer has the pivotal role in increasing crop production. Besides N and P, use of K has been reported to influence productivity of seed yield and seed oil contents (Ghosh *et al*., 1995). Kuo and Chen (1980) reported that K increased the seed oil content of Tower variety of rapeseed. Kandil (1983) reported that application of K along with N and P fertilizers improved seed yield of rape. Potassium plays a vital role in photosynthesis, translocation of photosynthesis, protein synthesis, control of ionic balance, regulation of plant stomata and water use, activation of plant enzymes and many other processes (Marschner, 1995; Reddya *et al*., 2004). Many studies have reported the significant variation among the canola genotypes in efficiency of N and P uptake and utilization (Svecnjak and Rengel, 2006; Yau and Thurling, 1987). Potassium known to increase pest resistance, as well as resistance to diseases and other biotic and abiotic environmental stresses (Reuveni and Reuveni, 1998; Zafar and Athar, 2013). Plant tissues contain higher K^+ ion than other cations. K regulates effectively many physiological and biochemical processes inside plants (Bajwa and Rehman, 1996). Potassium affects photosynthesis through ATP formation, regulates H_2O and CO_2 exchange through stomata as an osmo regulator, affects protein synthesis by activating enzyme nitrate reductase and transfers sugar to seeds (Wallace, 2001). Furthermore, potassium has a strong interaction with Nitrogen. Increase in the uptake of nitrogen has been reported due to increase in K level in barley (Armstrong, 1998), cowpea (Geetha and Varughese, 2001), cotton (Hassan and Arshad, 2010) and maize (Nawaz *et al*., 2006). About the same leaches down with irrigation and rain water (Wallace, 2001). The potassium use is almost negligible, the applied K to crops sometimes does not get proper response from crops, because applied K becomes fixed in the clay lattice and low K application hardly fulfills the soil thirst and yield is badly suffered (Bajwa and Rehman, 1996). Recent studies in Iran have shown the rate of decline in soil potassium has increased, and the potassium balance in many wheat fields has become negative. The reasons are intensive cropping, use of cultivars with a high nutrient demand, excessive application of nitrogen and phosphorous fertilizers and negligible use of potassium fertilizers. These have increased rates of potassium removal from soils faster than the rate of its release from the minerals (Olfati *et al*., 2010). Balasubramaniyan and Palaniappan (2001) reported when a soil is deficient in potassium, the crop yield reduced and had weak responses to nitrogen and phosphorus. Savaghebi and Malakouti (1999) reported applying potassium has significant effects on canola yield, and use of potassium sulfates at the rate of 150 $kg.ha^{-1}$ as the base fertilizer and 100 $kg.ha^{-1}$ potassium chloride for topdressing led to achieve maximum yield. Moreover, application of potassium reduced zinc deficiency resulting from applying phosphorous (Mirzashahi *et al*., 2010). Tabatabaei *et al*. (2014) reported effect of potassium sulphate was significant on number of spike per m^2, number of grain per spike, number of spikelet per spike, protein content, biological yield, seed yield and straw yield also highest of seed yield (6523 $kg.ha^{-1}$) was obtained from 160 $kg.ha^{-1}$ potassium sulphate application. Application of potassium increased absorption of zinc and boron by plants, led to considerable increases in yield (Munir and McNeilly, 1987). Sepehr *et al.* (2002) showed that potassium application at the rate of 50 kg $K.ha^{-1}$ increased grain yield and oil content of the sunflower significantly. Oil content progressively decreased with increase of potassium level the highest (42.86%) in case of control and the lowest (37.42%) with a potassium level of 150 kg $K.ha^{-1}$. However, a perusal of economic analysis showed that application of 125 kg $K.ha^{-1}$ potassium fertilizer was more economical than all other treatments. Ahmed *et al.* (2015) investigated response of several canola cultivars to different levels of potassium (K). They reported potassium applied at 60 $kgK.ha^{-1}$ is recommended for higher seed yield of several canola cultivars, however, for higher oil and protein content at 90 kg $K.{\cdot}ha^{-1}$ was recommended. The arable land under canola cultivation in Khuzestan province at southwest of Iran has considerably increased in recent years. Therefore, the logical strategy for making canola cultivation profitable, and for increasing farmers' inclination to grow this crop, is to reduce the existing limitations. Conditions such as high lime content of soil, alkaline pH, heavy texture, unsuitable potassium status in soils under cultivation and lack of sufficient knowledge about the required amount of potassium for canola under the prevailing conditions in Khuzestan province are factors limited its production. The trial under study intended to determine the most suitable source of potassium fertilizer and its optimum rate for increasing the qualitative and quantitative yield of canola in this province.

MATERIALS AND METHODS

Field and treatment information

To evaluate the effect of potassium sources and different levels of potassium fertilizer a research field conducted using combined analysis factorial experiment based on randomized complete blocks design during 2011-2013. Main factors consist of different types of potassium fertilizer included: potassium sulfate (PS) and potassium chloride (PC) and different levels of potassium fertilizer consist of 0, 100, 150 and 200 $Kg.ha^{-1}$ arranged sub factors. Geographical information of research field consisted 48 27′33″E longitude and 32"37' 0 N latitude in Khuzestan province (Located at south west of Iran). Absolute monthly maximum temperature is 51C°, maximum and minimum relative humidity is 73 and 27%, respectively and the average annual rainfall is 241.7 mm. Soil physical and chemical properties were shown in Table 1.

Table 1. Some soil characteristics analysis

Depth (cm)	ECe ($ds.m^{-1}$)	pH	O.C (%)	Soil texture	P ($mg.kg^{-1}$)	K ($mg.kg^{-1}$)
0-30	3.8	7.3	0.82	Clay Loam	8.1	230

O.C: Organic Carbon, pH: potential hydrogen, EC: Electrical Conductivity, P: Phosphorus, K: Potassium.

The chemical fertilizers (except potassium) applied based on soil testing. The rate of the N fertilizer (urea) applied in equal amounts at tillering stage and at the beginning of stem elongation. The phosphorous fertilizer and potassium fertilizers treatments applied before planting. Canola seeds of the Hyola401 hybrid planted and Treflan herbicide used for weed control as soil application. The area plots were 21 m^2. The irrigation plots was done base on moisture monitoring methods by soil samples and weighting wet and dry samples before irrigation.

Traits measurements

In order to determine the yield components during physiologic maturity, 10 plants were chosen randomly from each plot. Then 1000-grain weight, capsule in plant and seed in capsule were assessed. In final harvest area, one- square meter of each plot, seed yield were calculated. In addition, seed samples were dried, weighed and analyzed for oil content. Oil content determine by Near Infrared Spectroscopy (Sato, 2002). Results for oil content expressed on 8.5 % moisture. Oil yield calculated by multiplying seed yield by oil concentration.

Statistical Analysis

Analysis of variance and mean comparisons were done via MSTAT-C software and Duncan multiple range test at 5% probability level.

RESULT AND DISCUSSION

Capsule in plant

Results of combined analysis of variance (ANOVA) showed the effect of potassium source and potassium level and interaction of the treatments on capsule in plant were significant at 5% probability level (Table 2). According to the result of means comparison of different types of potassium fertilizer, potassium chloride had higher capsule in plant (280.8) than to potassium sulfate (201.2) (Table 3). Means comparison of different level of potassium fertilizer showed 200 $kg.ha^{-1}$ (287.7) and 150 $kg.ha^{-1}$ had higher number of capsule in plant than other treatments (Table 4). It seems increasing the rate of potassium fertilizer led to increase capsule in plant. Means comparison of interaction effect of potassium source and potassium rate showed the highest and the lowest amount of capsule in plant belonged to 200 $kg.ha^{-1}$ potassium chloride at (304.5) and control (244.7) treatment, respectively (Table 5). These results are in agreement with finding of some researchers (Ghosh *et al.*, 1993; Misras, 2003; Sultana *et al.*, 2007; Tuncturk and Ciftici, 2007).

Seed Yield

According to the results of combined analysis of variance, the effect of potassium source on seed yield was not significant but effect of potassium level and interaction of the treatments were significant at 5% probability level (Table 2). Means comparison of different type of potassium fertilizer indicated potassium chloride had higher seed yield (1801.46 $kg.ha^{-1}$) than to potassium sulfate (1634.6 $kg.ha^{-1}$) (Table 3). Maximum seed yield was gained in 100 kg $K.ha^{-1}$ (1802 $kg.ha^{-1}$), however it does not have significant difference between 150 and 200 kg $K.ha^{-1}$ treatments. The lowest seed yield (1555 $kg.ha^{-1}$) was quantified with zero K. Furthermore, maximum seed yield was gained in 100 kg $K.ha^{-1}$; however, this increase was not significant to the control. These results are in agreement with finding of some researchers (Fanaei *et al.*, 2009; Fusheing, 2006; Jianwei *et al.*, 2007; Ma *et al.*, 2015). Interaction effect of potassium source and potassium rate indicated that 100 and 150 $kg.ha^{-1}$ potassium chloride treatments had higher seed yield (2128, 1929 $kg.ha^{-1}$, respectively) compared to another treatments, while the lowest amount of seed yield belonged to 150 $kg.ha^{-1}$ potassium sulfate (1475 $kg.ha^{-1}$) (Table 5). This may be due to the higher salt index of potassium chloride, but at low application rates of potassium chloride, it has more potassium compared to potassium sulfate.

Table 2. Analysis of variance of measured traits

S.O.V	df	Capsule in plant	Seed in capsule	1000-seed weight	Seed yield	Oil yield	Oil content
Year	1	2301.5 ns	778.38 ns	9.66 ns	8734.52**	3258.76*	629.3 ns
Y × Replication	4	4956.3	10.00	0.095	87838.21	1283.9	0.385
Potassium source	1	4621.7*	17.46ns	0.041ns	3341.88 ns	6684.1*	0.801 ns
Potassium rate	3	2018.5*	1.94ns	0.02 ns	1517.3*	2773.6 ns	7.043**
Potassium sources × Potassium levels	3	936.96*	13.13ns	0.017 ns	4922.1*	118436.7**	15.97**
Year × Potassium source	1	1789.5ns	8934.4ns	910.7ns	3891.2ns	1845.3ns	691.9ns
Year × Potassium level	3	2798.2ns	210.3ns	812.1ns	1201.7ns	9103.8ns	19.6ns
Year × Potassium source × Potassium level	3	652.2ns	6791.8ns	875.1ns	365.1ns	5242.7ns	6491.7ns
Error	28	1518.6	6.51	0.014	110554.7	20928.4	0.462
CV (%)		7.38	8.7	3.51	9.5	2.47	1.72

ns: non-significant differences, *, **: significant differences at 1 and 5%, respectively.

Table 3. Means comparison effect of different source of potassium fertilizer on measured traits

Treatment	Capsule in plant	Seed in capsule	1000-seed weight (gr)	Seed yield ($Kg.ha^{-1}$)	Oil yield ($Kg.ha^{-1}$)	Oil content (%)
PS	201.2b	18.04a	3.38a	1634.6b	636.59b	39.27a
PC	280.8a	19.25a	3.43a	1801.46a	711.23a	39.52a

* According to Duncan's multi range test, the means of treatments with similar letters are not significantly different at 5% probability level. PS: Potassium Sulfate, PC: Potassium Chloride.

Table 4. Means comparison effect of different level of potassium fertilizer on measured traits.

Treatment	Capsule in plant	Seed in capsule	1000-seed weight (gr)	Seed yield ($Kg.ha^{-1}$)	Oil yield ($Kg.ha^{-1}$)	Oil content (%)
Control	216.6 c	18.2 a	3.38 a	1555 b	606.3 b	38.43 b
100 ($Kg.ha^{-1}$)	259.9 b	18.52 a	3.38 a	1802 a	720.2 a	40.14 a
150 ($Kg.ha^{-1}$)	274.9 a	18.68 a	3.45 a	1784 a	684.0 b	39.39 a
200 ($Kg.ha^{-1}$)	287.7 a	19.16 a	3.43 a	1731 a	685.1 b	38.87 a

* According to Duncan's multi range test, Means with the same letters in each column was not significant difference at 5% probability level.

Thus, applied at the same rates of both, potassium chloride had a positive effect on increasing seed yield and salinity resulting from chlorine did not cause any limitations for canola. However, in 200 kg $K.ha^{-1}$, seed yield declined compared to application of potassium sulfate because of the increased effects of the chlorine ion and salinity. Ghazian Tafrishi *et al.* (2009) reported application of potassium fertilizer significantly resulted in an increase in number of grains per pod and grain yield in all cultivars while it had no significant effect on grain oil content. Furthermore, the highest number of pods per branches was obtained in hybrid Hyola 401 when the highest amount of potassium (100 $kg.ha^{-1}$) and zinc (10 kg ha^{-1}) fertilizers were applied. Hyola 401 also showed the best performance among cultivars in response to the application of fertilizers, implying its high ability to receive more fertilizer.

Oil yield

Results of combined analysis of variance revealed that effect of potassium source on oil yield trait was significant at 1% probability level but effect of different level of potassium fertilizer was not significant, also interaction of treatments were significant at 1% probability level (Table 2). Potassium chloride had higher oil yield (711.23 kg.ha^{-1}) than to potassium sulfate (636.59 kg.ha^{-1}) (Table 3). 100 kg K.ha^{-1} (720.2 kg.ha^{-1}) had the highest oil yield (Table 4). Applied potassium fertilizer had positive effects on this trait compare to control treatment. Interaction effect of potassium source and potassium rate indicated the highest and the lowest oil yield belonged to 100 kg.ha^{-1} potassium chloride (878 kg.ha^{-1}) and 100 kg.ha^{-1} potassium sulfate (562.3 kg.ha^{-1}) treatment, respectively (Table 5). Oil yield depends on seed oil contents and seed yield of oilseed crops. Potassium chloride fertilizer was more effective in increasing oil yield compared to potassium sulfate. Moreover, the individual effects of application different rates of potassium indicated there were no significant differences among the different level of application with respect to increasing oil yield (Except 100 kg K.ha^{-1}). Some studies confirmed result of this study (Bahrani and Pourreza, 2016; Fanaeia *et al*., 2009; Kamali Dehkordi and Soleymani, 2012; Zou and Lu, 2010).

Table 5. Means comparison interaction effect of potassium source and rate on measured traits

Treatment		Capsule in plant	Seed in capsule	1000-seed weight (gr)	Seed yield (kg.ha^{-1})	Oil yield (kg.ha^{-1})	Oil content (%)
Control		244.7 ^{b}	16.10 ^{b}	3.36 ^{ab}	1543 ^{bc}	584.8 ^{bc}	38.30 ^{b}
PS	100 Kg.ha^{-1}	261.3 ^{ab}	18.12 ^{ab}	3.30 ^{b}	1475 ^{c}	562.3 ^{c}	38.93 ^{b}
	150 Kg.ha^{-1}	268.0 ^{ab}	19.02 ^{ab}	3.46 ^{a}	1638 ^{bc}	630.7 ^{bc}	38.63 ^{b}
	200 Kg.ha^{-1}	270.8 ^{ab}	18.91 ^{ab}	3.42 ^{ab}	1883 ^{abc}	768.5 ^{ab}	41.22 ^{a}
PC	100 Kg.ha^{-1}	258.5 ^{ab}	18.93 ^{ab}	3.46 ^{a}	2128 ^{a}	878.0 ^{a}	41.35 ^{a}
	150 Kg.ha^{-1}	281.8 ^{ab}	18.34 ^{ab}	3.46 ^{a}	1929 ^{ab}	737.3 ^{abc}	38.23 ^{b}
	200 Kg.ha^{-1}	304.5 ^{a}	19.41 ^{ab}	3.45 ^{ab}	1580 ^{bc}	601.7 ^{bc}	38.52 ^{b}

* According to Duncan's multi range test, Means with the same letters in each column was not significant at 5% probability level. PS: Potassium Sulfate, PC: Potassium Chloride.

Oil Content

According to the results of combined analysis of variance, effect of potassium source on oil content was not significant but effect of potassium level and interaction of treatments were significant at 1% probability level (Table 2). There were no significant differences between different types of potassium fertilizer (Table 3). The maximum percentage of oil content in canola seeds (40.14%) was in the treatment receiving potassium fertilizer at 100 Kg.ha^{-1}, but this oil percentage was not significantly different from those of the treatments receiving other application rates of potassium (Table 4). The effects of the source of potassium fertilizer and its application rate on percentage oil content of canola seeds were positive. The maximum percentages of oil content in canola seeds of 41.35 and 41.22% belonged to the treatments of applying potassium chloride at 100 kg.ha^{-1} and potassium sulfate at 200 kg.ha^{-1}, respectively (Table 5). Another researchers such as Cheema *et al*. (2012) and Hassan *et al*. (2005) reported same result.

CONCLUSION

Potassium chloride was better than potassium sulfate for achieve higher yield and its components. Finally, for increasing canola yield according to the result of this research 100 kg.ha^{-1} potassium chloride recommended and more rates should be considered to planting conditions.

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