INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 14, No. 5, p. 13-19, 2019
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

Impact of fertility regimes on the growth, seed yield and oil content of canola

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Article published on May 30, 2019

Key words: Canola crop, Fertilizer, Plant growth, Seed production, Oil content.

Abstract

In order to investigate the effect of different fertility regimes on the growth, seed yield and oil content of the canola crop. The Nitrogen (N), phosphorus (P), and potassium (K) were mixed and applied at different levels. The results of the NPK @ 120kg 60kg and 100kg ha^{-1} took 81.33 days to flowering, 117.33 days to maturity, 157.33 cm plant height, 660 pods plant^{-1}, 14.66 seeds pod^{-1}, 0.058g seed weight pod^{-1}, 3.43g seed index value, 2477.33kg seed yield ha^{-1} and 41.64% oil content. NPK @ 120-60-75kg ha^{-1} resulted flowering in 81 days, maturity in 116.33 days, 158cm plant height, 667.66 pods plant^{-1}, 14.99 seeds pod^{-1}, 0.059g seed weight pod^{-1}, 3.45g seed index value, 2497.33kg seed yield ha^{-1} and 42.75% oil content. Similarly, NPK @ 90-60-75kg ha^{-1} resulted flowering in 78 days, maturity in 114 days, 152cm plant height, 677.33 pods plant^{-1}, 15.22 seeds pod^{-1}, 0.060g seed weight pod^{-1}, 3.48g seed index value, 2553.66kg seed yield ha^{-1} and 43.34% oil content. It was concluded that application of N-P-K fertilizers at the rate of 90-60-75kg ha^{-1} proved to be an optimum fertility regime for economical canola production, because seed yield of highest under 90-60-75kg ha^{-1} and either with increase or decrease over this N-P-K rate adverse effects on almost all the parameters were noted. Moreover, inverse situation was noted in case of oil content and as the N-P-K rate increased, the oil content was simultaneously decreased.

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Introduction

Edible oil is one of the single largest items used by human beings worldwide. Pakistan is facing a chronic deficiency in edible oil because its domestic production does not match with annual demand in consumption. The major oilseed crops include cottonseed, rapeseed/mustard, sunflower and canola etc. The total productivity of edible oils in 2015-16 was 3.73 million tons. Local production stood at 0.46 million tons contribute 14% of the oil production.

Canola is a genetically altered form of rapeseed which is comprised of two species: *Brassica rapa*, known as Polish canola; and *Brassica napus*, known as Argentine canola. Until the early 1990s, *Brassica rapa* was referred to as *Brassica campestris* (Klahorst, 2007). A review of this classification by taxonomists in the late 20th Century found that the two plants in fact belonged to the same species and were cross-fertile. Since *Brassica rapa* was the name first associated with the species, the decision was made to eliminate the use of the term *Brassica campestris* in favour of *Brassica rapa* (Fallon and Enig, 2002)

The role of chemical fertilizers levels cannot be overemphasized and their balanced and efficient use improves the quality of crops, increase the nutrient value and increases plant resistance to diseases and climatic changes. The major three elements are nitrogen, potassium and phosphorus (Barlog and Grzebisz, 2004). Fertilizers improve the productivity of the soil. N, P and K are the synthetic fertilizers, which are inorganic fertilizers formulated in suitable dosage and balanced supply three main nutrients: nitrogen, phosphorus and potassium for crop production (Laaniste *et al.*, 2004). Nitrogen promotes plant growth and forms chlorophyll, phosphorus and proteins contributes to root, flower and fruit development; while Postssium help in development of root and stem and in the synthesis of proteins (Malik *et al.*, 2002). Phosphorous is relatively immobile (moves very little) in the soil (Vasilyuk and Shapsheeva, 2004).

Combined application of N, P and K influence the growth and yield of crop significantly; and Tahir *et al.,* (2003) received maximum seed yield of 3.5 tons ha^{-1} under 100-60-50kg NPK ha^{-1} and oil contents decreased with increasing NPK rates. The combined FYM+NPK fertilizer application gave significantly higher yields as compared to NPK or FYM by 8.3 and 12.7%, respectively (Blecharczyk *et al.*, 2004) and NPK application increased the nutrient uptake in the grain and straw. Khan *et al.*, (2004) found that in *Brassica napus* the highest seed yield (3473kg ha^{-1}), 1000-seed weight (6.63g), biological (23020kg ha^{-1}) and seed yields (3473kg ha^{-1}) were obtained with K at 150kg ha^{-1} and maximum protein content (22.37%) was obtained with K at 150kg ha^{-1}. Mustard was the crop that charged the nutrient balance in the highest degree and an average annual surplus for this crop exceeded 80kg N ha^{-1} (Stalenga *et al.*, 2004). On the above hypothesis, the experiment was conducted to investigate the influence of different fertility regimes on the growth and seed yield of canola.

Materials and methods

Experimental site and layout

The experiment was conducted at Ghuram Farm (under Agriculture Extension based experiments),Tahsil Dera Allahyar, District Jaffarabad, Balochistan during 2013-2014 in a three replicated randomized complete block design (RCBD) keeping the sub-plot size of 5m × 2.7m (13.5m2).

Commercial canola variety "Rainbow" was examined in this experiment. Seedbed was prepared considering the recommendations to this effect and the seed of commercial variety "Rainbow" was sown by drilling method using single coulter drill in 45cm apart rows. The spacing within the rows was maintained at 5cm. Nitrogen was applied in the form of urea (46% N), Phosphorus in the form of DAP (46% P_2O_5) and K in the form of SOP (50% K_2O). All P and K along with half of nitrogen was applied at the time of sowing by mixing in the soil, while the remaining nitrogen was divided into two equal splits and was applied at 2nd and 3rd irrigation. All the agronomic practices were carried out uniformly in all the plots. For data collection five plants were selected randomly from each treatment.

Data analysis

The collected data were subjected to statistical analysis, using analysis of variance to ascertain the significance level of the differences between treatments, while L.S.D. (Least Significant Differences) test was employed to examine the significance difference within treatments. The statistical analyses were performed through computer using software M.Stat-C , Steel and Torrie (1980).

Results and discussion

Days taken to flowering

Significantly maximum number of days to flowering (81.33) was taken by the crop fertilized with N-P-K at the rate of 120-60-100kg, while crop fertilized with NPK at the rates of 120-60-75 and 90-60-75kg ha^{-1} took 81.00 and 78.00 days to flowering, respectively (Table 1). The canola crop took relatively lesser number of days i.e. 74.70 and 70.66 to flowering when crop was fertilized with NPK rates of 90-30-75 and 60-30-50kg ha^{-1}, respectively. The days to flowering was further diminished to 69.33 and 65.33 when NPK rates were decreased to 60-30-0 and 60-0-0kg ha^{-1}, respectively. The minimum number of days to flowering was recorded in case of the 60kg N and no P or K.

Number of days taken to maturity

Significantly maximum number of days to maturity (117.33) was taken by the crop received N-P-K at the rate of 120-60-100kg ha^{-1}, while crop that received N-P-K at the rate of 120-60-75 and 90-60-75kg ha^{-1} took 116.33 and 114.00 days to maturity, respectively (Table 1).

The crop matured relatively earlier in 112.00 and 108.66 days when fertilized with N-P-K rates of 90-30-75 and 60-30-50kg ha^{-1}, respectively. The canola crop was matured even more early in 103.00 and 100.66 days when N-P-K rates were decreased to 60-30-0 and 60-0-0kg ha^{-1}, respectively. Hence, the minimum number of days to maturity was recorded in case of crop received only nitrogen at 60kg ha^{-1} and no P and K application.

Plant height (cm)

The canola crop received N-P-K at the rate of 90-30-75 and 60-30-50kg ha^{-1} resulted mean plant height of 149.00cm and 140.00cm on average, respectively; while height of canola plants was further significantly ($P<0.01$) deteriorated to 136.00 and 133.33cm when the crop was fertilized with comparatively lower N-P-K rates of 60-30-0 and 60-0-0kg ha^{-1}, respectively (Table 1).

The canola plants in plots received only nitrogen and no P and K grew lowest in height as compared to the NPK treated crop, irrespective of rate of fertilization. Statistically, the differences in plant height between 120-60-75 and 120-60-

100kg N-P-K ha^{-1} were non-significant (P>0.05) and similar was the situation when plant height was compared under N-P-K rates of 60-30-0 and 60-30-50kg ha^{-1}. The results indicated that canola crop responded significantly to different concentrations of nutrients and plant height was simultaneously improved with increased NPK rates upto 120-60-75kg ha^{-1}, further increase in NPK rates did not have significant effect on plant height, even adverse effects were noted. In a similar study, Vasilyuk and Shapsheeva (2004) found that the growth characters were distinctly higher under liquid nitrate (N) as compared to other sources and different application patterns significantly influenced the growth of brassica plant (Malik *et al*., 2002).

Table 1. Mean values for various growth contributing characters of canola as influenced by different fertility regimes.

Fertility regimes (NPK kg ha^{-1})	Days to flowering	Days to maturity	Plant height (cm)	No. of Pods plant^{-1}
T1=60-0-0	65.33 e	100.696 d	133.33 d	354.33 e
T2=60-30-0	69.33 d	103.00 cd	136.00 c	416.66 d
T3=60-30-50	70.66 d	108.66 c	140.00 c	478.66 c
T4=90-30-75	74.00 c	112.00 bc	149.00 b	587.00 b
T5=90-60-75	78.00 b	114.00 a	152.00ab	677.33 a
T6=120-60-75	81.00 a	116.33 a	158.00 a	667.66 a
T7=120-60-100	81.33 a	117.33 a	157.33 a	660.00 a
S.E.±	0.3299	1.0987	1.6523	11.3256
LSD 0.05	1.482	3.163	5.225	41.6523
LSD 0.01	2.018	4.834	7.348	57.8563
CV%	3.38	4.12	3.39	4.91

Number of pods per plant

The fertility regimes had significant (P<0.01) effect on the number of pods per plant and significantly highest number of pods (667.66) per plant was noted in plants fertilized with N-P-K at the rate of 120-60-75kg ha^{-1}, while canola crop fertilized with N-P-K at the rates of 120-60-100 and 90-60-75kg ha^{-1} produced 660.00 and 677.33 mean number of pods per plant, respectively (Table 1). The canola crop received NPK at the rate of 90-30-75 and 60-30-50kg ha^{-1} produced 587.00 and 478.66 mean number of pods per plant, respectively. The number of pods per plant was further depreciated significantly (P<0.01) to 416.66 and 354.33 when N-P-K rates were decreased to 60-30-0 and 60-0-0kg ha^{-1}, respectively. The results further indicated a remarkable decrease in the number of pods in plots receiving only N and no P or K fertilizers. These results have further been supported by Barlog and Grzebisz (2004) who found that N in the two-split system improved yield components considerably.

Number of seeds per pod

Significantly highest number of seeds (15.22) per pod was noted in plants fertilized with N-P-K at the rate of 90-60-75kg ha^{-1}, while canola crop fertilized with N-P-K at the rates of 120-60-75, 120-60-100 and 90-30-75kg ha^{-1} produced 14.99, 14.66 and 14.66 mean number of seeds per pod, respectively. The canola crop received N-P-K at the rate of 60-30-50 and 60-30-0kg ha^{-1} produced 11.99 and 11.44 mean number of seeds per pod, respectively (Table 1). The number of seeds per pod was further fallen significantly (P<0.01) to 10.11 when only N was applied at the rate of 60kg ha^{-1} and P and K were stopped where a remarkable decrease in the number of seeds per pod was recorded over P or K fertilized plots.

The differences in number of seeds per pod between N-P-K rates of 90-30-75, 90-60-75, 120-60-75 and 120-60-100kg ha^{-1} were statistically non-significant (P>0.05), this indicated that there was no economical impact on the number of seeds per pod if N-P-K is applied beyond the rate of 90-30-75kg ha^{-1}. Thus, the N-P-K at the rate of 90-30-75kg ha^{-1} was an optimum fertility regime for this character. The studies on potassium requirements of *Brassica* species have also been reported from Faisalabad, Pakistan by Khan *et al*., (2004) and found greater number of pods under combined application NPK fertilizers.

Weight of seeds per pod (g)

Significantly maximum weight of seeds (0.060g) per pod was noted in plants fertilized with N-P-K at the rate of 90-60-75kg ha^{-1}, while canola crop fertilized with N-P-K at the rates of 120-60-75 and 120-60-100kg ha^{-1} produced 0.059 and 0.058g mean weight of seeds per pod, respectively. The canola crop received N-P-K at the rate of 90-30-75, 60-30-50 and 60-30-0kg ha^{-1} produced 0.057, 0.048 and 0.040g mean weight of seeds per pod, respectively (Table 2). The weight of seeds per pod was further decreased considerably (P<0.01) to 0.035g when only N was applied at the rate of 60kg ha^{-1} and P and K were stopped and hence, there was considerable decrease in weight of seeds per pod in absence of P and K. The results showed that weight of seeds per pod between N-P-K rates of 90-60-75 and 120-60-75kg ha^{-1} were statistically non-significant (P>0.05) and under highest N-P-K rate of 120-60-100 adverse effects on weight of seed per pot were recorded. This showed that there was no economical impact on the weight of seeds per pod if N-P-K is applied beyond the rate of 90-60-75kg ha^{-1}. Thus, the N-P-K at the rate of 90-60-75kg ha^{-1} was an optimum fertility regime. These results are in concurrence to those of Stalenga *et al*., (2004) who reported higher seed weight under combined NPK application at higher rates.

Seed index value (1000 seeds weight g)

The fertility regimes had significant (P<0.01) effect on the seed index value and significantly maximum seed index value (3.48g) was recorded in plots fertilized with N-P-K at the rate of 90-60-75kg ha^{-1}, while canola crop fertilized with NPK at the rates of 120-60-75 and 120-60-100kg ha^{-1} produced 3.45 and 3.43g mean seed index value, respectively (Table 2). The crop received NPK fertilizers at the rate of 90-30-75 and 60-30-50kg ha^{-1} resulted seed index value of 3.28 and 3.21g, respectively. The seed index value was decreased significantly (P<0.01) to 3.11 and 2.99g when NPK rates were decreased to 60-30-0 and 60-0-0kg ha^{-1}, respectively. The seed index value was reached to its lowest when the crop was left untreated with P and K and only N was supplied. Statistically, the differences in seed index value between N-P-K rates of 90-60-75, 120-60-75 and 120-60-100 kg ha^{-1} were non-significant (P>0.05); this indicated that 90-60-75kg ha^{-1} was an optimum fertility regime, because further increase in their rates adversely affected this character. The above results are partially supported by the findings of various researchers from different parts of the world (Hegde and Babu, 2004; Khan *et al*., 2004; Stalenga *et al*., 2004), who were of the experience that different NPK regimes had significant influence on seed index value of canola and other brassica plants.

Seed yield (kg ha^{-1})

The fertility regimes had significant (P<0.01) effect on the seed yield and maximum seed yield (2553.66kg ha^{-1}) was recorded in plots fertilized

with N-P-K at the rate of 90-60-75kg ha^{-1}, while canola fertilized with NPK at the rates of 120-60-75 and 120-60-100kg ha^{-1} produced seed yield of 2497.33 and 2477.33kg ha^{-1}, respectively (Table 2). The crop fertilized with NPK fertilizers at the rate of 90-30-75 and 60-30-50 and 60-30-0kg ha^{-1} produced average seed yield of 2478.33, 2145.00 and 2031.33kg ha^{-1}, respectively.

The canola seed yield declined significantly ($P<0.01$) to 1831.66kg ha^{-1} when N was applied at the rate of 60kg ha^{-1} without P and K; hence, seed yield was lowest in this situation in absence of P and K. The results further showed that reduction in nitrogen caused a severe soil N deficiency and hence poor seed yields, while absence of phosphorus and potassium also caused a considerable decrease in seed yield. Either increase or decrease in N-P-K rates over 90-60-75kg ha^{-1} showed adverse effects on seed yield of canola variety Rainbow; thus 90-60-75kg ha^{-1} was proved to an optimum fertility regime for economic canola production. The findings reported by Tahir *et al.*, (2003), Barlog and Grzebisz (2004), Laaniste *et al.*, (2004), Vasilyuk and Shapsheeva (2004), Malik *et al.*, (2002) and Khan *et al.*, (2004) are in line with the findings of present investigation and they all have reported increased seed yields of canola under combined application NPK fertilizers.

Table 2. Mean values for seed yield, its contributing characters and oil content of canola as influenced by different fertility regimes.

Fertility regimes (NPK kg ha^{-1})	No. of seeds plant^{-1}	Weight of seeds (g plant^{-1})	1000 seeds weight (g)	Seed yield (kg ha^{-1})	Oil content (%)
T1=60-0-0	10.11 c	0.035 b	2.99 c	1831.66 e	44.43 a
T2=60-30-0	11.44 b	0.040 ab	3.11 c	2031.33 d	44.30 ab
T3=60-30-50	11.99 b	0.048 ab	3.21 b	2145.00 c	44.11 ab
T4=90-30-75	14.66 a	0.057 ab	3.28 b	2478.33 b	43.89 b
T5=90-60-75	15.22 a	0.060 a	3.48 a	2553.66 a	43.34 c
T6=120-60-75	14.99 a	0.059 a	3.45 a	2497.33 b	42.75 d
T7=120-60-100	14.66 a	0.058 ab	3.43 a	2477.33 b	41.64 e
S.E.±	0.2631	0.0004	0.005	8.3012	0.0736
LSD 0.05	1.2440	0.016	0.054	37.29	0.3318
LSD 0.01	1.504	0.023	0.073	50.77	0.4507
CV%	3.37	2.13	3.41	5.59	2.45

Oil content (%)

The NPK rates had significant ($P<0.01$) effect on the oil content of canola, and significantly maximum oil content (44.43%) was recorded in seed obtained from the plots fertilized with 60kg N without P and K, while crop fertilized with NPK at the rates of 60-30-0 and 60-30-50kg ha^{-1} resulted oil contents of 44.30 and 44.11%, respectively (Table 2). The average oil content was decreased gradually to 43.89 and 43.34% in the seeds received from the crop fertilized with NPK rate of 90-30-75 and 90-60-75kg ha^{-1}, respectively. The oil content was further reduced to 42.75 and 41.64% when NPK rates were applied at higher rates of 120-60-75 and 120-60-100kg ha^{-1}, respectively. The oil content was gradually decreased with increasing N-P-K rates. There was a gradual decrease in oil content of canola seed with each increased fertility rate. However, there was no association of absence of phosphorus and potassium to influence the oil content. In the present study, inverse situation was noted in case of oil content and as the N-P-K rate increased, the oil content was simultaneously decreased.

Similar results have been reported by Tahir *et al*., (2003) who reported that the seed oil contents decreased significantly with increasing rate of NPK fertilizers; while Laaniste *et al*., (2004) applied 120kg N ha^{-1} and revealed that different N levels influenced the oil content and dry matter in mustard.

Conclusions

After thorough scrutiny of the results of the present study, it was concluded that application of N-P-K fertilizers at the rate of 90-60-75kg ha^{-1} proved to be an optimum fertility regime for economical canola production, because seed yield of highest under 90-60-75kg ha^{-1} and either with increase or decrease over this N-P-K rate adverse effects on almost all the parameters were noted. Moreover, inverse situation was noted in case of oil content and as the N-P-K rate increased, the oil content was simultaneously decreased.

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