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Effect of NPK Levels on Seed Yield and Oil Contents of Canola

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Abstract

A field study was conducted to investigate the effect of different nitrogen, phosphorus and potassium levels on seed yield and oil contents of canola (Brassica napus L.) during 1999-2001. Levels of NPK were 0-0-0, 50-0-0, 0-30-0, 50-30-0, 50-30-50, 100-30-50, 100-60-50, 100-90-50, 100-90-100 and 150-90-100 kg ha^{-1}. All P,K and 1/2 N was side drilled at sowing time and the remaining 1/2 N was top dressed at early flowering with second irrigation. Various yield components such as number of pods plant-1, seeds pod-1 and 1000-seed weight were affected significantly by different levels of N, P and K. The highest seed yield and net income was obtained in treatment with 100-60-50 kg NPK ha-1 may be due to optimum improvement in components of yield. The number of pods plant-1, seeds pod-1 and 1000-seed weight were greater in the treatment (100-60-50 kg NPK ha^{-1}) than all other treatments. Significant decrease in oil contents with increasing rates of NPK levels (especially N) reflects inverse relationship between oil concentration and seed protein contents. The results show that seed and oil yields of canola were maximized at the treatment with 100-60-50 kg NPK ha^{-1} under the agro-ecological conditions of Faisalabad, Pakistan.

Key words: *Brassica napus L*, Canola, NPK fertilizer, Seed yield, Oil content

Introduction

The rapeseed and mustard group is the second most important source of edible oil after cotton in Pakistan. With the evolution of cultivars low in erucic acids, it is possible to produce problem-free edible oils from rapeseed and mustard in Pakistan. However, for newly introduced crops, it is necessary to assess the appropriate production technology to different environments. Amongst many others, the nutritional requirements of the crop are considered to be the most important factor. Nitrogen (N), phosphorus (P) and Potassium (K) play a vital role in crop yield. Holmes and Ainsley (1977), working on spring oilseed rape in Scotland, reported an average of 187-200 kg N ha^{-1} for high yield. Sheppard and Bates (1980) also noted increased yield with increasing N rates up to 100 kg ha^{-1}. Ibrahim *et al.* (1989), working in Egypt on spring rape, concluded that yield increased with rates of N up to 213 kg ha^{-1}. Allen and Morgan (1972) concluded that N increased the yield by influencing the number of pods plant^{-1}, the number of seeds pod^{-1} and 1000-seed weight. Excess N, however, can reduce seed yield and quality appreciably. High N applications were found to cause lodging (Scott *et al.*, 1973, Sheppard and Bates, 1980, Wright *et al.*, 1988 and Bailey, 1990). Holmes and Ainsley (1977), working in England and Scotland, observed a response to P at rates up to 60 kg ha^{-1}. High rates of applied P increased oil percentage (Bailey and Grant, 1990) or reduced it slightly (Henry and Schappart, 1971). When a soil is deficient in potassium, the crop yield is reduced and responses to nitrogen and phosphorus are small (Balasubramaniyan and Palaniappan, 2001).

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Materials and Methods

A field experiment was conducted on canola cv. Hyola-401 at the Agronomic Research Area, University of Agriculture, Faisalabad during 1999-2001. A randomized complete block design (RCBD) was used. The experiment was replicated three times. The net plot size was 2.4 x 5.1m. The treatments were 0-0-0. 50-0-0, 0-30-0, 50-30-50, 100-30-50, 100-60-50, 100-90-50, 100-90-50, 100-90-100 and 150-90-100 kg NPK ha^{-1}. Air dried soil samples were analysed for physical and chemical properties in both years. The crop was sown during the second week of October, using a seed rate of 5 kg ha^{-1} in 60 cm apart paired row strips (60/20 cm). Crop was thinned twice to maintain plant to plant distance of 15cm. Urea, tripe super phosphate (TSP) and potassium sulphate (K_2SO_4) were used as source of nitrogen, phosphorus and potash, respectively. Whole of phosphorus potash and half of nitrogen was side drilled at sowing and the remaining half of nitrogen was top dressed at early flowering with second irrigation. The crop was irrigated three times, first four weeks after the emergence of crop, second at flower initiation and third at seed formation stage. The crop was kept free of weeds by giving one hand hoeing before first irrigation and plant protection measures against aphids were followed by spraying twice, methamidophos @ 100 ml ha^{-1}. All other agronomic practices were kept uniform and normal for all the treatments. The total number of pods per 10 randomly selected plants from each plot was collected and then averaged. Similarly, the number of seeds in all the pods of

10 plants was counted and then averaged per pod. Three samples each of 1000 seeds were taken at random from the seed lot (mean total seed yield obtained from each plot) of each plot and weighed and their average was calculated. Oil contents of seeds were estimated using an nuclear magnetic resonance test (Robertson and Morrison, 1979).

The sun-dried biomass in each plot was threshed manually, and the seed yield per plot was recorded and then converted to kg ha^{-1}. The harvest index was calculated as the ratio of seed yield to total biological yield and was expressed as a percentage.

The pooled experimental data were analysed by using the methodology described in CIMMYT (1988) for economic analysis. The data were statistically analysed using MSTAT-C (Freed and Scott, 1986). Analysis of variance techniques were employed (Steel and Torrie, 1984) to test the overall significance of the data, while Duncan's Multiple Range (DMR) test at P = 0.05 was used to compare the treatment means.

Results and Discussion

Number of pods $plant^{-1}$

There were significant differences among the treatments for number of pods $plant^{-1}$ during both the seasons (Table-1). The number of pods $plant^{-1}$ increased with increasing rates of N,P and K upto 100 kg N + 60 kg P + 50 kg K ha^{-1} in both the seasons. Thereafter, it slightly declined at higher rates of fertilizer application in both the seasons. During 1999-2000 T_7 (100-60-50 kg ha^{-1} NPK) produced significantly maximum number of pods $plant^{-1}$ which was, however, statistically on a par with T_6, T_8 and T_9 treatments while the minimum number of pods $plant^{-1}$ were obtained in control (T_1) which in turn was found statistically at par with T_3. In 2000-2001 maximum number of pods $plant^{-1}$ was also recorded in T_7 which, however, did not differ statistically from that of T_8. Minimum number of pods $plant^{-1}$ were recorded in control (T_1). Plots with inadequate or imbalance ratio of nutrients (fertilizer) produced less number of pods $plant^{-1}$. Higher number of pods in treatments T_7 (100-60-50 kg ha^{-1} NPK) was probably due to balanced ratio of NPK influencing positively the parameter under discussion. These results are in line with those of Bajpai *et al.* (1992); Chauhan *et al.* (1995); Arthamwar *et al.* (1996) and Cheema (1999) who reported that increasing the rate of N and P fertilizer increased pods number over control treatment.

Number of seeds pod^{-1}

Different levels of NPK had significant effect on number of seeds pod^{-1} of canola during the year 2000-2001 but non-significant in 1999-2000 (Table-1). There was an increase in number of seeds pod^{-1} with an increase in NPK applications upto T_7(100-60-50 kg ha^{-1} NPK), after which, a decline in number of seeds pod^{-1} was recorded. The treatment T_7 produced significantly more number of seeds pod^{-1} (25.12) than all other treatments. The adequate application of fertilizer especially nitrogen supply enables the crop to make rapid leaf growth to intercept more solar radiation and thus to produce and fill pods. Similar results in *Brassica* spp. were reported by others (Allen and Morgan, 1972; Bajpai *et al.* 1992; Chauhan *et al.*, 1995; Vallioud, 1974; Cheema, 1999).

1000-seed weight

During 1999-2000 seeds were heavier than those in 2000-2001. In the first season the maximum 1000-seed weight (4.21g) was recorded for the crop fertilized with 100 kg N + 60 kg P_2O_5 + 50 kg K_2O ha^{-1} which was, however, statistically on par with T_2, T_4, T_5, T_6, T_8, T_9 and T_{10} treatments. On the contrary, the lowest 1000-seed weight (3.67 g) was noted for control (T_1) which, in turn, was statistically at par with T_2, T_3, T_4 and T_5 treatments. In 2000-2001 again the same treatment 100-60-50 kg ha^{-1} NPK (T_7) had the maximum 1000-seed weight (4.13g) which, however, did not differ statistically from that of T_6,T_8,T_9 and T_{10} treatments. While the minimum 1000-seed weight (3.60g) was noted in control (T_1) which was also statistically at par with T_2 and T_3 (Table 1). These results substantiate the findings of Tayo and Morgan (1975) who reported average seed weight of 3.28 g/1000 seeds in *Brassica napus*. As the timely supply of assimilates to the pod (seed) plays a crucial role in the development of seed and probably plants with greater and balance supplies of nutrients produced heavier seeds than those under no or limited application of N,P and K alone or in combination. Similar results were reported by Allen and Morgan, 1975.

Seed yield

Data in Table 1 show that increasing rate of fertilizer application significantly enhanced seed yield over lower rates of fertilizer application in both the seasons. In 1999-2000, the maximum seed yield (3539 kg ha^{-1}) was recorded for the crop fertilized with 100-60-50 kg ha^{-1} NPK (T_7), that was, however, statistically on a par with T_8, T_9 and T_{10} treatments. On the contrary, the crop grown without fertilizer (T_1) exhibited the lowest seed yield (2595 kg ha^{-1}). Similar trend was observed in 2000-2001. In the present study seed yield of canola increased in response to higher rates of fertilizer application over control (T_1) or lower rates of application with maximum mean yield of 3502 kg ha^{-1} obtained from T_7 (100-60-50 kg ha^{-1} NPK) in both the seasons. The maximum seed yield in T_7 is attributable to maximum number of pods $plant^{-1}$, seeds pod^{-1}, and 1000-seed weight. Gammellvind *et al.* (1996), working in Copenhagen, reported seed yield about 2800 to 4800 kg ha^{-1} in winter oilseed rape. He also noted a decrease in seed yield at the higher rate of fertilizer applications, a result similar to that found in the present study and also Hocking *et al.* (1997) working in Australia.

Table 1: Seed yield, yield components, oil content and yield of canola as affected by different N, P and K applications

Treatment				No.of pods plant^{-1}		No. of seeds pod^{-1}		1000-seed weight (g)		Seed yield(kg ha^{-1})		Harvest index (%)		Oil content(%)		Oil yield (kg ha^{1})	
T	N	P	K	1999-2000	2000-2001	1999-2000	2000-2001	1999-2000	2000-2001	1999-2000	2000-2001	1999-2000	2000-2001	1999-2000	2000-2001	1999-2000	2000-2001
	(kg ha^{-1})																
T_1	0	0	0	309.30f	303.10h	20.23	19.82f	3.67c	3.60e	2595f	2543e	19.70d	19.74e	44.53a	44.57a	1156c	1134c
T_2	50	0	0	331.80de	325.00f	21.81	21.37e	3.81abc	3.73cde	2897de	2838d	21.02bc	21.09cd	43.24bc	43.30bc	1253d	1229d
T_3	0	30	0	318.50ef	312.10g	22.25	21.79e	3.75bc	3.67de	2857e	2798d	21.19bc	21.24cd	43.60b	43.65b	1246d	1221d
T_4	50	30	0	345.60cd	338.50e	22.65	22.18de	3.88abc	3.80cd	3045cd	2983c	21.30bc	21.36cd	42.78c	42.82c	1303cd	1277cd
T_5	50	30	50	356.40c	349.20d	23.56	23.07c	3.96abc	3.88bc	3158c	3092c	21.41b	21.49cd	42.60c	42.63c	1345bc	1318bc
T_6	100	30	50	388.10ab	380.00bc	24.50	24.02b	4.09ab	4.01ab	3359b	3289b	21.55b	21.64bc	41.80d	41.83d	1404ab	1376ab
T_7	100	60	50	404.90a	396.60a	25.66	25.12a	4.21a	4.13a	3539a	3464a	22.58a	22.75a	41.68d	41.71d	1475a	1445a
T_8	100	90	50	399.00ab	390.60a	23.80	23.31bc	4.20a	4.11a	3535a	3460a	22.46a	22.60a	41.51d	41.54d	1468a	1438a
T_9	100	90	100	392.40ab	384.00b	23.50	22.98cd	4.17a	4.09a	3514ab	3441a	22.23a	22.35ab	41.36d	41.40d	1454a	1425a
T_{10}	150	90	100	382.00b	374.00c	22.60	22.13de	4.13ab	4.04ab	3438ab	3366ab	20.67c	20.77d	38.74e	38.82e	1332cd	1307bc

NS = Non-significant

Means followed by the same letter in a column do not differ significantly at $P \leq 0.05$ by Duncan's multiple range test.

Table 2: Economic analysis of canola as affected by different nitrogen, phosphorus and potassium applications during 1999-2000 and 2000-2001

Treatment				Gross income	Total expenditure	Net income (NFB)	Increase over control (%)
T	N	P	K		(Rs. ha^{-1})		
	(kg ha^{-1})						
				1999-2000			
T_1	0	0	0	40247	12070	28177	
T_2	50	0	0	44815	12896	31919	13.26
T_3	0	30	0	44183	12787	31396	11.42
T_4	50	30	0	47082	13613	33469	18.78
T_5	50	30	50	48818	14813	34005	20.68
T_6	100	30	50	51913	15640	36273	28.73
T_7	100	60	50	54601	16357	38244	35.73
T_8	100	90	50	54551	17074	37477	33.00
T_9	100	90	100	54247	18274	35973	27.67
T_{10}	150	90	100	53219	19100	34119	21.09
				2000-2001			
T_1	0	0	0	39437	12070	27367	-
T_2	50	0	0	43897	12896	31001	13.25
T_3	0	30	0	43267	12787	30480	11.37
T_4	50	30	0	46118	13613	32505	18.77
T_5	50	30	50	47792	14813	32979	20.50
T_6	100	30	50	50824	15640	35184	28.56
T_7	100	60	50	53430	16357	37073	35.47
T_8	100	90	50	53381	17074	36307	32.66
T_9	100	90	100	53109	18274	34835	27.29
T_{10}	150	90	100	52095	19100	32995	20.56

Price/40 kg
Canola seed = Rs. 600.00
Canola straw = Rs. 5.00

Cost (Rs. per 50 kg bag)
DAP = Rs. 680.00
Urea = Rs. 380.00
TSP = Rs. 550.00
K_2SO_4 = Rs. 600.00

Harvest index

Effect of various levels of N,P and K on harvest index is reflected from the data presented in Table 1. Increasing rate of fertilizer application increased harvest index upto T_7 (100-60-50 kg ha^{-1} NPK) treatment in both the seasons, thereafter it started decreasing with higher levels of fertilizer application. In 1999-2000 crop fertilized @ 100 kg N + 60 kg P_2O_5 + 50 kg K_2O ha^{-1} (T_7) exhibited maximum HI (22.58%) which was however, statistically on a par with T_8 and T_9 treatments. On the contrary, the lowest HI (19.70%) was noted in T_1 (control). Almost similar trend was recorded in 2000-2001.Lower seed yield in control plot or plots with inadequate NPK supply resulted in lower HI. These results are supported by those of Cheema (1999) who reported that increasing rate of fertilizer application increased harvest index upto 90-60 NP kg ha^{-1}, thereafter it decreased significantly with higher rate of fertilizer application. Similarly harvest indices of about 20-22% of different *Brassica* spp. were reported by Kasa and Kondra (1986).

Oil contents

Different levels of N,P and K application significantly affected seed oil contents in both the years of study. In 1999-2000 significantly maximum oil contents (44.53%) were found in T_1(control) where no fertilizer was added (Table-1). While, T_{10} treatment (150-90-100 kg ha^{-1} NPK) gave significantly the lowest oil contents (38.74%). However, the treatments T_6,T_7 T_8 and T_9 were statistically at par with each other. In 2000-2001, a similar trend of seed oil contents was noted. The higher rates of fertilizer application significantly reduced the oil contents than lower rates of fertilizer application or control treatment. Significant decrease in oil percentage of the canola and other oilseed crops with increasing nitrogen were reported by many workers (Zhao *et al.*, 1993; Hocking *et al.*, 1997). Oil contents similar to the present study were also reported by others (Asare and Scarisbrick, 1995; Hocking *et al.*, 1997; Cheema, 1999).

Oil yield

Oil yield depends on seed oil contents and seed yield of oilseed crops. Different levels of N,P and K application significantly affected oil yield in both the years of present study. During 1999-2000 the maximum oil yield (1475 kg ha^{-1}) was recorded for T_7 (100 kg N + 60 kg P_2O_5 + 50 kg K_2O ha^{-1}) which, however, did not differ statistically from T_6, T_8 and T_9 treatments. The significantly minimum oil yield (1156 kg ha^{-1}) was observed in T_1 (control). In 2000-2001, a similar trend of oil yield was noted (Table-1). The oil content(%) in T_{10} treatment was significantly less from T_6,T_7,T_8 and T_9 treatments, therefore, total oil yield in T_{10} was also less as compared with these treatments. These results are in line with those of Asare and Scarisbrick (1995), Hocking *et al.* (1997) and Cheema (1999).

Economic analysis

The economic analysis (Table 2) indicated higher net income ha^{-1} in T_7 treatment over all other rates of fertilizer applications including control treatment in both the years. Maximum net return obtained in T_7 treatment was Rs. 38244 ha^{-1} in 1999-2000 and Rs. 37073 ha^{-1} in 2000-2001.

Fertilizer at 100 kg N, 60 kg P_2O_5 and 50 kg K_2O ha^{-1} significantly increased seed and oil yields in both the years. The maximum seed and oil yields obtained were 3539 and 1475 kg ha^{-1} and 3464 and 1445 kg ha^{-1} in 1999-2000 and 2000-2001, respectively.

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