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Dual Purpose Cropping to Improve Farm Productivity under Nitrogen and Planting Density Management Strategies

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Abstract: Dual purpose (DP) canola is new concept refers to the utilization of a crop as animal feed before seed production. Canola has both the potential for seeds and grazes due to its best regeneration power without much yield penalty. An experiment was conceded to probe the responses of cutting treatments, nitrogen levels and timing of application and planting density on phenology and yield traits of canola. The results indicated that no-cut plots took lesser days to flowering as compared to cut and grazed plots. Similarly, no-cut plots also took minimum days to maturity than grazed and cut plots. Application of 120 kg N ha^{-1} enhanced the pods $plant^{-1}$, seeds pod^{-1} seed yield than 80 kg N ha^{-1}. However, early flowering and minimum days to pods initiation were pragmatic with use of 80 kg nitrogen ha^{-1}. Nitrogen in two splits enhanced seed yield as compared to single or three splits. Similarly, plant density of 20 plants m^{-2} formed more pods $plant^{-1}$ as compared to plant density of 40 plants m^{-2}.

Key words: Grazing · Dual purpose · Canola · Nitrogen · Timings

INTRODUCTION

Canola ranks third in number in terms of oil production after soybean and palm. Canola belongs to crucifer group and is considered to be an important edible oil source for human consumption as its seed contains 36-49% protein [1]. Canola acreage is increasing day by day and becoming a plant of major agro-economics because of its high nutritive values [2]. The worldwide production of canola is 72 million tons cultivated on 36 million ha^{-1}[3]. The presence of glucosinolate (less than 30 μ mole g^{-1}) and erucic (less than 2%) acids in rapeseed in high amount is considered to be toxic for both humans and livestock [4].

Like other developing countries, Pakistan has also acute and serious shortage of edible oil because of low cultivation and production of oilseed crop, most of the edible oil required is imported from different developed countries and the government is paying billions of rupees each ear for this import. During 2012-13 our requirement was 3.069 million tones with local production of 0.567 million tones. The domestic production covers only 18% of our requirement. The rest of 82% demand was imported upon spending huge budget part. Pakistan being an agriculture country producing just 830 kg ha^{-1} [5] indicating a huge gap than other advanced countries. However, agriculturally developed countries have a yield level of 3200 kg ha^{-1} (Canada) and 2000 kg ha^{-1} Australia for canola crop [6]. To narrow down this gap concrete efforts are needed to increase its local production.

Factors responsible for low yields may be unavailability of good seed, low organic matter and other cultural practices. But, lack of balanced nutrition is one of the major problems in obtaining potential yield of the canola crop. Appropriate and timely nutrition plays significant role in producing high yields of different crops. Among the nutrients, nitrogen (N) is a major nutrient element playing a significant role in plants healthy growth [7]. Nitrogen is a key element and plays a vital role in different plant process like increase cell size, protoplasm, photosynthesis activity and an essential precursor for protein synthesis [8]. More over higher doses of nitrogen also had negative impacts on crop yield as well as quality. Thus, application of fertilizer with accurate amount and feasible timing is essential for boosting the yield of any crop.

An optimum planting density is the key for producing high yield in canola. Higher density increased the competition among the plants for resources like nutrients, light, water etc. whereas lower density limits

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production in the sense the overuse of the resources. Planting density is an essential feature and had noticeable effects on economic yield of any crop. Planting density in canola crop governs the individual plant yield and ultimately the final yield [9]. Proper planting density is mandatory and considered to be pre requisite for higher yield production [10]. Fathi *et al*. [11] reported that manipulating planting density in canola crop caused a significant boost in seed yield and pick seed yield was noticed with planting density of 90 plants m^{-2}. Similarly, Salehian *et al*. [12] also reported promising results with increasing planting density and improved yield and yield components were observed in plots with planting population of 110 plants m^{-2}.

Keeping in view the importance of canola as a dual purpose crop, nitrogen fertilizer and its application timings under varying planting density the current experiment was carried out to study canola growth and investigate about the rate and timings of N fertilizer with varying planting densities.

MATERIALS AND METHODS

Site Description: The current trail was conducted at Agronomy research farm of Agriculture University Peshawar, Pakistan (34°1'21''N, 71°28'5''E), in *rabi* season of 2012-13. The experimental site has silty clay soil, pH 7-7.5 and low organic matter content of 0.845 g kg-%. [13][14].

Experimental Procedure: Canola (Cv. Abasyn-95) seeds were sown on Oct. 24th, 2012. Sowing was done with the help of hand hoe with a consistent seed rate of 8 kg ha^{-1} in all plots. The trial was reputed in split plot arrangement of randomized complete block design replicated three times. Cuttings treatments (No-cut, cut and grazed) and nitrogen levels (80 and 120 kg ha^{-1}) were selected for main plots while, nitrogen application timings (sole at sowing, 1/2 each at sowing and rosette stage and 1/3 at sowing, rosette and late rosette stage) and planting density (20 and 40 plants m^{-2}) were assigned to sub plot. Every sub experimental unit was comprised of 7 rows, 3 m long and 50 cm apart from each other.

Phosphorus and potash were added @ of 60 kg ha^{-1} from Triple Superphosphate (TSP) and Muriate of Potash (MOP), respectively before sowing. In order to maintain the required planting density thinning was done in the field. Cutting and grazing was done after 70 days of emergence. All the agronomic practices were carried out.

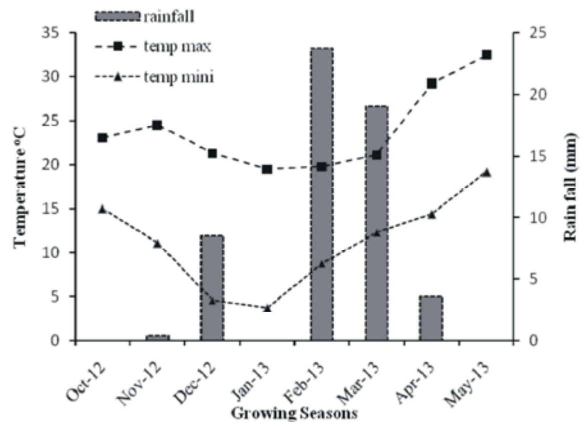

Fig. 1: Weather data of site.

RESULTS

Number of Days to Flowering: Data on days to flowering are shown in Table 1. The data showed that cutting treatments (C) and nitrogen levels (NL) had a significant effects on days to flowering while the effects of nitrogen application timings (NT) and planting density (PD) were found non significant. All interactions were found non significant. Grazed plots took more days to flowering followed by cut plots, while lesser days to flowering were taken by no-cut plots. Addition of 120 kg N ha^{-1} delayed flowering as compared with 80 kg N ha^{-1}.

Days to Pods Initiation: Data on days to pods initiation are shown in Table 1. Pods initiation showed significant response to C and NL. The effects of PD and NT were not significant. None of the interactions was significant for days to pod initiation. Grazing delayed pods initiation as compared to no-cut and cut plots. Higher number to pods initiation was recorded with applying of 80 kg N ha^{-1} in comparison with the plots that received 120 kg N ha^{-1}.

Days to Maturity: Data on days to physiological maturity of canola are shown in Table 1. Days to maturity were significant effect by cuttings. However, the effects of NL, PD and NT were not significant. Likewise, all interactions were not significant. Cutting and grazing delayed maturity of canola as compared to no-cut plots.

Number of Pods Plant^{-1}: The effects C, NL, PD and years as source of variation were significant on number of pods plant^{-1} of canola. The effect of NT was found non significant. All interactions were found non significant (Table 2). Higher number of pods plant^{-1} was observed in no-cut plots followed by grazed and cut plots.

Table 1: Days to flowering, pods initiation and days to maturity of canola as affected by cutting treatments, nitrogen levels and application timings under varying planting densities.

Treatments	Days to flowering	Days to pods initiation	Days to maturity
Cuttings ©			
No-cut	108 c	131 b	169 b
Cut	117 b	122 c	182 a
Grazed	122 a	136 a	180 a
$LSD_{(0.05)}$	1.25	1.6	2.96
Nitrogen levels (NL)			
80 kg ha^{-1}	114 a	130 a	177
120 kg ha^{-1}	116 b	129 b	176
Significance level	*	*	ns
N application timing (NT)			
Full at sowing	116	130	177
Half each at sowing and rosette stage	116	129	176
One third each at sowing, rosette and late rosette stages	115	129	176
$LSD_{(0.05)}$	ns	1.3	2.01
Planting density (PD)			
20 plants m^{-2}	116	129	177
40 plants m^{-2}	115	130	177
Significance level	ns	ns	ns
Interactions Significance level			
C x NL	ns	ns	ns
C x NT	ns	ns	ns
C x PD	ns	ns	ns
NL x PD	ns	ns	ns
NT x NL	ns	ns	ns
NT x PD	ns	ns	ns
C x NT X NL	ns	ns	ns
C x NT x PD	ns	ns	ns
NT x NL x PD	ns	ns	ns
C x NL x NT x PD	ns	ns	ns

ns = non significant, *=Significant at 5% level of probability.

Likewise, increasing nitrogen level significantly increased pods $plant^{-1}$. Maximum number of pods $plant^{-1}$ was counted with 120 kg N ha^{-1} than 80 kg N ha^{-1}. However, pods $plant^{-1}$ was decreased with increasing plant density for canola crop. Planting density of 20 plants m^{-2} produced higher number of pods than 40 plants m^{-2}.

Number of Seeds Pod^{-1}: Investigation of data revealed that C and NL had significant effected on seeds pod^{-1}. All interactions except C x NL remained non significant. However, NT and PD did not significantly affect number of seeds pod^{-1}. No-cut plots had higher number of grains pod^{-1} followed by cut plots whereas grazed plots produced least number of grains pod^{-1}. More number of seeds was produced pod^{-1} with adding of 120 kg N ha^{-1} than to 80 kg N ha^{-1}. The C x NL interaction showed that number of seeds pod^{-1} increased with increasing N (120 kg N ha^{-1}) in both cut and grazed plots than lower level of N (80 kg N ha^{-1}). However, no-cut plots did not show remarkable increase with increasing level of nitrogen (Fig 1).

Seed Yield (kg ha^{-1}): Data on seed yield indicated that C, NL and NT considerably affected grain yield of canola whereas there was no considerable effect of planting density (Table 2). Higher seed yield was recorded in no-cut plots followed by cut plots whereas lower seed yield was recorded in grazed plots. Addition of 120 kg N ha^{-1} increased seed yield than to 80 kg N ha^{-1}. Higher seed yield was resulted when N was applied in two splits as compared to either N applied full at sowing or in three splits. All the interactions were found significant.

Table 2: Number of pods plant^{-1}, seeds pod^{-1} and grain yield of canola as affected by cutting treatments, nitrogen levels and application timings under varying planting densities.

Variables	Number of pods plant^{-1}	Number of seeds pod^{-1}	Seed yield
Cutting treatments ©			
No-cut	278 a	17 a	1291a
Cut	258 c	16 b	983 b
Grazed	264 b	15 b	886 c
$LSD_{(0.05)}$	7.15	0.83	72
Nitrogen levels (NL)			
80 kg ha^{-1}	260 b	16 b	1022 b
120 kg ha^{-1}	274 a	17 a	1086 a
Significance level	*	*	*
N application timings (NT)			
Full at sowing	269	16	1025 ab
Half each at sowing and rosette stage	266	16	1058 a
One third each at sowing, rosette stage and late rosette stages	265	16	1019 b
$LSD_{(0.05)}$	ns	ns	38.3
Planting density (PD)			
20 plants m^{-2}	275 a	16	1066
40 plants m^{-2}	266 b	16	1044
Significance level	*	ns	ns
Interactions	Significance level		
C x NL	ns	*	ns
C x NT	ns	ns	ns
C x PD	ns	ns	ns
NL x PD	ns	ns	ns
NT x NL	ns	ns	ns
NT x PD	ns	ns	ns
C x NT X NL	ns	ns	ns
C x NT x PD	ns	ns	ns
NT x NL x PD	ns	ns	ns
C x NL x NT x PD	ns	ns	ns

ns = non significant, *=Significant at 5% level of probability.

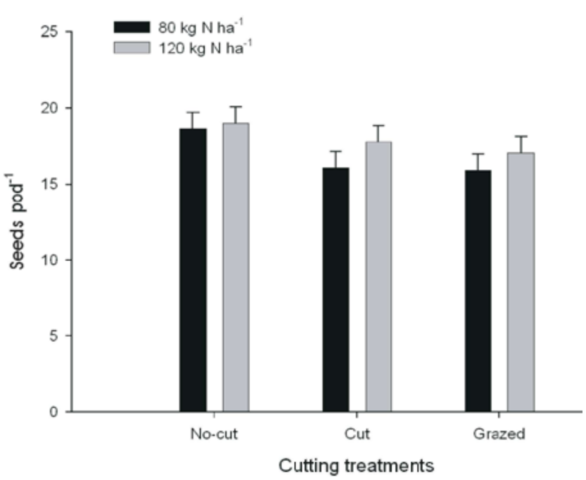

Fig. 1: Interaction between nitrogen levels and cutting treatments for seeds pod^{-1}. Vertical bars represent $LSD_{(0.05)}$.

DISCUSSION

Delay in phenological traits due to grazing or cutting depends on the intensity of grazing, stage of crop growth and the removal of leaves or stem [15,16]. In present study, grazing delayed flowering by 14 days as compared to cut treatment. Pod initiation was earlier in cut plots by 14 and 9 days as compared to grazed plots and no-cut plots, respectively. Grazing and cutting delayed physiological maturity by 11 and 13 days, respectively as compared to no cut plots. The probable reason for substantial delay in these traits in grazed or cut plots might be due to the heavy grazing, removal of main stem and delay in re-growth of the plant parts. Likewise, the removal of auxiliary buds due to grazing is the apparent reason for delay in flowering and pods initiation in grazed plots [17]. Similarly, other studies Kirkegaard *et al.* [18]

and Sprague *et al*. [19] also reported that heavy grazing especially of leaves and stems delayed flowering by 10-14 days while light grazing i.e. only leaves delayed flowering by 4 days[16]. Virgona *et al*. [20] also reported that reduction in photosynthetic activity due to removal of leaves might be the reason of delayed physiological maturity of the crop.

Yield parameters are among the important measurements while determining or evaluating the compliance of a crop to any ecological disparity. They are vital parameters and considered to be the end products of any management strategies. The dual purpose canola is grown for both optimum fodder and grain yield. The scope of dual purpose cropping system is rising day by day due to fodder shortfall and higher beef price over grain [21]. Cutting treatments caused significant differences in seeds pods^{-1}, pods plant^{-1} and seed yield of canola crop. Higher seed yield was noted in no-cut plots, while lower yield was recorded in grazed plots. Similarly, higher pods plant^{-1} and seeds pod^{-1} was produced in no-cut plots when compared with grazed and cut plots. Due to less re-growth ability of plants in cut and grazed plots they were unable to regenerate quickly and reach to the growth of plants of no cut plots. Reason for this substantial decrease in yield of grazed and cut plots might be removal of main stem either manually or by grazing with sheep. Our findings are supported by Laba *et al*. [22] who recorded reduction in seed yield due to cuttings 14 days before flowering in their experiment Kirkegaard *et al*. [15] reported that grazing or defolitiation at flowering stage reduced seeds pod^{-1} and pods plant^{-1}

Increase in N level from 80 to 120 kg ha^{-1} delayed flowering by one day. Whereas, nitrogen timing was found insignificant for days to maturity. It might be due to the fact that N application tends to promote vegetative growth of the crop and hence prolonged vegetative growth and delayed flowering in canola crop. Kutcher *et al*. [23] found that maturity of canola was delayed with increasing N up to 120 kg ha^{-1}. 120 kg N ha^{-1} produced 6% more pods plant^{-1} as compared with 80 kg N ha^{-1}. Increase in pods plant^{-1} due to higher N application showed the effectiveness and positive response of canola to N fertilizer [10]. Likewise, Cheema *et al*. [24] also observed increase (30%) in the number of pods with 120 kg N ha^{-1} as compared to unfertilized treatment. It might be due to the reason that N fertilization stimulated the growth and other processes which improved pods number. Similarly, 6% increase was recorded with 120 kg N ha^{-1} than 80 kg N ha^{-1}. Qayyum *et al*. [25] also found more number of grains pod^{-1} with elevation of N level from 0 to 120 kg ha^{-1}.

Application of N fertilizer in Split is an efficient way to utilize the dose properly and to minimize the risk of its volatilization. It was found in this study that plots treated with split application of N fertilizer produced higher number of pods as compared to sole N application. Our results are in conformity with Afridi *et al*. [26], who observed significant differences in split and sole application of N fertilizer and found split application a better option. The study of Diepenbrock [10] also found that splitting N fertilizer increases the NUE and hence increases the pods plants^{-1}. Optimum supply of nitrogen fertilizer enables the plants to increase leaf growth and hence improve solar radiation interception. Nitrogen levels significantly affected seed yield of canola in our trails. Split application of N fertilizer provides flexibility in their fertilizer program. Whole application at once requires high moisture to be utilized which is not possible in most of the cases, so splitting of N fertilizer is getting popularity among the farmers. Higher seed yield was noted in plots where N was applied in two splits as compared with sole N application. Cheema [27] reported that split application benefits the crop growth and ensure availability of nutrients at proper time which may result in high grain yield. Cheema *et al*. [24] reported that application of N fertilizer in split form increased seed yield by 11% as compared to sole application

Planting density is an important factor which determines the yield and is individually affected by the climatic conditions and production system of an area as well [28]. Generally, pods number decreases with increase in plant density (PD). The maximum number of pods was recorded in plots where PD of 20 plants m^{-2} was maintained as compared with 40 plants m^{-2}. Increasing the planting density caused decrease in canola pods number. Keivanrad *et al*. [29] reported 86.70, 79.50 and 73.68 pods plant^{-1} with planting densities of 80, 100, 120 plants m^{-2}, respectively which clearly indicated that increasing planting density decreased the pods plant^{-1}. Similarly, Morrison *et al*. [30] also suggested that canola with high density may produce smaller pods in size. However, some studies showed an inverse relation for number of pods and planting population. Bahrani and Babaei [31] showed that thickening the density of canola caused increase in shadowing, decrease in flowers per branch and hence resulted in minimum number of pods branch^{-1} and pods plant^{-1}. Similarly, Leech *et al*. [32] also indicated that increasing the density significantly decreased pods plant^{-1}. The reason they presented for less number of pods is that sunlight penetration in high density planting is less which reduced branching and thus led to decreased pods plant^{-1}. In our study, planting density had non significant effects on seed yield which indicated that 20 and 40 plants m^{-2} gave similar results regarding seed yield of canola. Whereas, Cheema *et al*.[24] reported that higher yield in least densities indicated the proper utilization and maximum facilitation of nutrients. Likewise, least densities also offered enormous canopy with less contest among the plants [33].

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