Research Article

Pheno-morphological traits of Canola as influenced by nitrogen and green manuring crops (species, parts and age) under semiarid condition

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Abstract

Field experiments were conducted at the Agriculture Research Institute Tarnab, Peshawar to study the impact of two green manuring crop species (guar and millet), their age (40, 70 and 100 days after sowing, DAS) and parts (whole plants and stubbles) under varying nitrogen levels (0, 75 and 100 kg ha⁻¹) on pheno-morphological traits of canola (*Brassica napus* L. cv. Bulbul-98). Findings of the experiments revealed that guar as preceding green manuring crop had significantly increased plant height (8%), leaf area (18%) and biological yield (12%). Incorporation of whole plant green manuring had increased leaf area (3%) and biological yield (4%) along with delayed maturity of canola crop. Green manuring age had significantly affected leaf area plant⁻¹ and biological yield. Leaf area increased when the age of green manuring increased from 40 DAS to 70 DAS; however, it decreased when green manuring was done at the plant age of 100 DAS. Dwarf plants and decrease in BY with the age of incorporation (100 DAS) were observed. Nitrogen application had significantly affected all the parameters except emergence m⁻². Increasing N level from 0 to 100 kg ha⁻¹ had enhanced LA and BY. Years had significantly influenced all parameters except emergence m⁻² and leaf area plant⁻¹. In the second year of the experiment, delayed maturity, taller plants and higher biological yield was observed than the first year. It was concluded from this study that incorporation of whole plants of guar as a green manuring crop at either 40 or 70 DAS along with 100 kg N ha⁻¹ resulted improved pheno-morphological traits of canola under semiarid condition.

Keywords: Canola, Green manuring, Nitrogen, Incorporation, Phenology, Morphology.

Introduction

Rapeseed (*Brassica napus* L.) is an important oil seed crop throughout the world

which ranked third among the oil seed crops after soybean and palm in production of vegetable oil [1]. It is widely grown in

winter season in irrigated and rain fed areas of Pakistan. Winter oil seed rape has become a plant of major agro-economic importance, with a yield of 62.2 million tons [2]. The presence of high amounts of erucic acid and glucosinolates in rape seed oil is considered toxic for human and animal health, in addition to its bitter taste, has imposed serious health concerns. Safe limits for these compounds have been described as less than 2% erucic acid in oil and less than 30 μ mole g^{-1} of glucosinolates in oil free meal [3]. The newly introduced "double zero" canola varieties have low erucic acid and glucosinolates amounts, made canola oil more popular among the consumers in Pakistan [4]. Pakistan is suffering from acute deficiency in edible due to multiple factors. Pakistan major reliance is on the import of edible oil spending more than 2.5 billion US\$ for bridging up the gap between edible oil demand and the domestic production. The total edible oil requirements of the country in 2012 13 were around 3.069 million tones with domestic production of only 0.567 million tones (18%) while the rest of 2.52 million tons (82%) of demand is imported [5]. Pakistan yield of canola is 830 $kg\ ha^{-1}$ [6], which is very low as compared to other agriculturally advanced countries of the world like Australia and Canada where average yield ranges from 2000-3000 $kg\ ha^{-1}$ [7]. Nutrient deficiency is one of the major limiting factors causing lower productivity in Pakistan [8]. Nitrogen deficiency is one of the major yield limiting factors [9]. Nitrogen fertilization plays an important role in improving soil fertility and increasing crop productivity [10]. Nitrogen is an integral component of amino acids, proteins, nucleotides, chlorophyll, chromosomes, genes and is also a constituent of all the enzymes. This wide range of different nitrogen containing plant compounds explains the role of nitrogen in

plant growth [11]. Compared to cereals, winter oilseed rape requires a higher amount of nutrients and available nitrogen which is worth to be considered in relation to its role in affecting its quality and quantity. Optimum level of nitrogen application can significantly increase production per unit area. Grain quality is directly related with N fertilization, as little but frequent increase has been observed in grain protein content by N fertilization [12]. The increase in yield and yield components of canola with the increasing N rates has also been reported by [4, 13] and many other researchers. Green Manuring is a useful mean of sustaining organic matter in the soil and thereby enhances the biological activity, improve soil physical properties and increase nutrient availability. Green manuring is the reliable option for sustainable cultivation. Green manuring alone or in combination with nitrogen fertilizer have positive effects on plant growth and production as well as on soil physiochemical properties [14]. The increased uptake of nitrogen by plants when residues were incorporated was also reported by [15]. Organic matter build up through green manuring has declined over the years as legumes have been virtually eliminated from the cropping systems, which led to serious deterioration of soil fertility. Despite of the great potential of legumes and their significant N contribution towards improving soil fertility, the adoption of legumes is poor due to wide range of physical and socio-economic conditions [16]. Cultivation of legumes for seed, fodder or green manure has not only helped in improving soil fertility through nutrient recycling, has positively influenced the structure and functioning of the agro ecosystem. Several workers have shown that crop yield and product quality are usually improved when legumes are grown as a preceding crop [17]. Legume residues

retention improves the N economy of the cropping system and enhances the crop productivity through the additional N and many other potential benefits [18]. Combined applications of inorganic N and crop residue as organic source can be an efficient sustainable practice but choice of appropriate N application rate is evenly significant [19]. This study tried to examine improvement in phenological and morphological traits of canola. Keeping in view the importance of nitrogen and green manuring, the present experiment was designed with the following objectives.

1. To determine the best crop specie as a green manuring for enhancing Phenomorphological traits of canola.
2. To determine the optimum age of the crop for green manuring.
3. To determine the best N level for higher yield of canola.
4. To study the relationship between crop species, green manuring, its age at green manuring and N level on the performance of canola.

Materials and Methods

Experimental Site

Field experiments were conducted at Agricultural Research Institute Tarnab, Peshawar, Pakistan. The institute is situated at a distance of 16 km to the east from Peshawar city a capital of Khyber Pakhtunkhwa province at 33° N latitude, 71° E longitude and an elevation of 360 meters above the sea level. Temperature and rainfall during the experimental years have been shown in Fig.1 and 2. Mean monthly minimum temperature ranged from 1.0° C in January to 14.5° C in October and maximum temperature ranged from 17.2° C in January to 31.6° C in October during the year 2011-12. While mean monthly minimum temperature ranged from 1.0° C to 13.8° C and maximum temperature ranged from 17.7° C to 30.5° C in 2012-13. Total

rainfall recorded during the experimental years was 184.3 mm in 2011-12 and 75.26 mm in the year 2012-13. The rainfall was much higher in 2011-12 than the 10 years average rainfall (64.49 mm) of the project area.

Experiment Detail

The experiment titled " Phenomorphological traits of canola as influenced by green manuring, green manuring crops and age at green manuring under varying levels of nitrogen" was conducted at Agriculture Research Institute Tarnab, Peshawar. The experiment was conducted for a period of two years i.e. 2011-12 and 2012-13. Seed of high yielding, improved canola cultivar "Bulbul-98" was obtained from ARI, Tarnab, Peshawar.

Experimental Procedure

In summer 2011, two crops i.e. millet and guar were sown with normal cultural practices. These crops were harvested at 40, 70 and 100 days after sowing. The above ground biomass thus produced was chopped, weighted and either removed or incorporated (known quantity) in the same plots. In case of removal of above ground biomass only the stubbles and roots were incorporated. Keeping the same plot demarcations, in winter season, 2011 canola variety Bulbul-98 was sown on the already established plots. The same experiment was repeated for the second year in 2012. A uniform seed of canola (5 kg ha⁻¹) was sown in all the plots through hand hoe. In each plot there were 8 rows 5 m long and 50cm apart with a plot size of 4 m x 5 m. Nitrogen was applied at the rate of 0, 75 and 100 kg ha⁻¹ in the form of urea. A basic dose of phosphorus and potash fertilizer at the rate of 60-60 kg ha⁻¹ was applied prior to sowing with seed bed preparation. The experiment was laid out in Randomized Complete Block Design (RCBD) with split plot arrangement. A combination of crop age at green

manuring and crop species were allocated to main plots while combination of green manuring and nitrogen were applied to sub plots. In order to obtain optimum plant population thinning was carried out at 30 days after sowing. Weeds were controlled manually. Irrigation was applied when needed. The crop was harvested in the month of April in both years.

Procedure for data recording

Emergence m^{-2} was recorded by counting the number of plants in one meter long row at three different places in each sub plot and the counts were then converted in to number of plants per m^2 . Leaf area (cm^2) was measured with the help of a leaf area meter (Licor Model 3000A, USA). Leaf area of ten leaves plant⁻¹ was measured at start of flowering as Brassica napus attain maximum leaf area at that stage [3]. Days to maturity were calculated by counting the number of days from the date of sowing to the date when the color of the pods turns from green to yellow in each sub plot. Plant height (cm) data was recorded by measuring the height of ten randomly selected plants in each sub plot at physiological maturity and then their average was calculated. For total biomass

yield, four central rows in each sub plot were harvested, dried and weighted and was converted as $kg\ ha^{-1}$. The data recorded were analyzed statistically combined over years using analysis of variance techniques appropriate for randomized complete block design with split plot arrangement. Main and interaction effects were compared at $P < 0.05$ level of probability using LSD test [20]. During both the growing seasons of the experiment temperature (Maximum and minimum) remains relatively similar. Maximum temperature of 30 C $^{\circ}$ at sowing (October) as well as harvesting (April) of the canola crop was recorded. Second year of the experiment (2012-13) has approximately 59% less rainfall however the rainfall was fairly was distributed as compared to 1st year (2011-12) where rainfall was concentrated only to January and April. As temperature remains identical during crop season and difference in rainfall was compensated with irrigation as per the demand of the crop, any difference in crop response could be related to the other factors of crop production imposed during the experiment.

Table 1. Average air temperature and rainfall at ARI, Tarnab, Peshawar during the crop growing season 2011-12 and 2012-13

Month	Min T (C $^{\circ}$)	Max T (C $^{\circ}$)	Average T (C $^{\circ}$)	Total Rainfall (mm)	Ten years average rainfall (mm)*
October	14.5(13.8)	31.6(30.5)	23.1(22.2)	26.10(10.15)	4.58
November	09.2(6.76)	26.7(25.0)	17.0(15.88)	15.80(0.00)	6.92
December	03.0(3.0)	20.9(20.2)	11.9(11.6)	0.00(15.00)	8.47
January	01.0(1.0)	17.2(17.7)	9.1(09.4)	58.80(4.00)	10.77
February	02.4(5.10)	17.5(19.1)	09.95(12.1)	22.60(20.70)	15.46
March	07.9(10.35)	24.9(24.77)	16.4(17.56)	9.80(11.41)	6.99
April	13.6(13.80)	30.2(29.6)	21.9(21.7)	51.2(14.00)	11.30
Total rainfall during the growing season				184.3(75.26)	64.49

without parenthesis = for crop season 2011-12

with parenthesis = for crop season 2012-13

* 10 years = 2002-03 to 2012-13

Results and Discussion

Emergence m^{-2}

Data regarding seedling emergence (m^{-2}) of canola are given in Table 2. Statistical analysis of the two years average data revealed that emergence (m^{-2}) was not significantly ($p < 0.05$) affected by green manuring crop (C), green manuring (GM), age at green manuring (AGM), nitrogen levels (N) and all the possible interactions which could be due to the fact that at the time of emergence seed indigenous food reserves are metabolized and used thus germination is usually is not affected by soil nutrients status.

Leaf area $plant^{-1}$

Leaf area $plant^{-1}$ (cm^2) of canola was significantly affected by C, GM, AGM and N levels. Interactions between AGM x C, C x GM x N, and C x AGM x N were also found significant for leaf area $plant^{-1}$. Guar sown as preceding green manuring crop showed maximum leaf area $plant^{-1}$ (1777 cm^2) of canola as compared to preceding millet sown plots (1456 cm^2) which could be due to the amount and availability of N due to guar as leguminous crop. Mean values for green manuring showed that plots where whole plants were incorporated had broader leaves (1644 cm^2) as compare to plots where only stubbles were incorporated (1593 cm^2). Green manuring at 70 days after sowing (DAS) had higher leaf area $plant^{-1}$ (1768 cm^2) while minimum leaf area $plant^{-1}$ (1483 cm^2) was recorded with green manuring at 40 DAS. Leaf area $plant^{-1}$ increased with the increase in N level and the highest leaf area $plant^{-1}$ (1744 cm^2) was recorded with 100 kg N ha^{-1} , while lowest leaf area $plant^{-1}$ (1507 cm^2) of canola was recorded in control plots (0 kg N ha^{-1}). These results are in conformity with the reported by [21] who reported an increase in leaf area in canola with the increase in nitrogen level.

Interaction between AGM x C (Fig. 1) showed that both the crops green manured at 70 DAS has increased leaf area $plant^{-1}$. Decline in leaf area $plant^{-1}$ was observed with delay in incorporation (100 DAS). In case of green manuring crop species, guar performed better when incorporated at the age of 70 DAS when compared to millet for boosting leaf area $plant^{-1}$. The interaction of C x GM x N (Fig. 2) revealed that the increase in N level irrespective of crop species or green manuring (incorporation or removal) increased leaf area $plant^{-1}$. Leaf area $plant^{-1}$ response to guar as a green manuring crop was more than millet. Increase in the yield, stem length and leaf surface area in spinach with the increase in the fertilizer N level is reported by [22]. Green manuring of whole plants as a whole was not beneficial in terms of increased leaf area $plant^{-1}$ when compared with stubbles only. The interaction of C x AGM x N (Fig. 3) indicated that with the increase in N level leaf area $plant^{-1}$ increased in both the crops irrespective of its age at green manuring. Leaf area $plant^{-1}$ responded well to incorporation at the age of 70 DAS in both the crops. Green manuring of guar was better than millet even without addition of N to guar. These results are supported by [23] who reported increase in leaf area with the increase in N level up 120 kg ha^{-1} in their study.

Days to maturity

Days to maturity of canola was significantly ($p < 0.05$) affected by GM and N levels while all the possible interactions were found non-significant. Perusal of the data indicated that plots with whole plants incorporation significantly delayed maturity (179 d) as compared to stubbles incorporated plots (178 d). Nitrogen application had significantly affected maturity. Plots with 100 kg N ha^{-1} supply took more days (179 d) to maturity as compared with no N supply,

however it was at par with 75 kg N ha⁻¹ application. The probable reason for this might be the additional N availability from guar being a leguminous which resulted delay in maturity. These results are in line with the findings of [24-26] who reported delay in maturity with the increase in nitrogen level. The 2nd year (2012-13) of the experiment took significantly more days to flowering which is probably due to carry over and accumulative effect of nutrients release from the residues decomposition after a year time.

Plant height

Data regarding plant height (cm) of canola revealed that C, AGM and N levels (N) and the interaction between C x AGM had significantly affected plant height (cm) of canola Table 1. Guar as preceding green manuring crop produced significantly taller plants (153 cm) as compare with millet sown plots (142 cm). Green manuring at 100 DAS had produced dwarf plants with height of 143 cm as compared with green manuring at 40 DAS or 70 DAS (152 cm). Increase in plant height when guar was sown as a preceding green manuring crop could be due to the sufficient availability of nitrogen in those plots when compared to millet sown plots. These results are in line with those reported by [27] who stated that legumes have a greater restorative effect of soil N than grasses and highlighted a beneficial role of legumes for the succeeding crops. Significant increase in plant height with the increase in N levels from 0 to 75 kg ha⁻¹ was recorded. Plant height did not significantly increased at the highest level of N (100 kg ha⁻¹). These findings are in agreement with the findings of [28-34] who reported that N fertilizers have a stimulating and direct impact on vegetative growth and development of plants. The increase in growth characters with the increase in nitrogen level might be due to the role of

nitrogen that is reflected in the form of taller plants.

The interaction between C x AGM (Fig. 4) showed that initially plant height of canola for both the green manuring crops when incorporated at 40 DAS was almost similar. In case of guar increase in plant height of canola was recorded at 70 DAS incorporation while millet showed different trend where plant height decreased with the age of green manuring. Plant height in both the crops decreased with the age of green manuring. The probable reason might be the fact that as plant matures its protein and other water soluble contents decreases steadily, whereas the amount of hemicelluloses, cellulose and lignin increases. Consequently, the residues of immature plants generally decompose readily than those of older plants [35]. These findings are confirmed by [9, 36, 37] who recorded an increase in soil organic matter by N inputs from both fertilizer N, by retention of residues and N₂ fixation by legumes. The organic matter content was increased after preceding or succeeding legume crops than after proceeding or succeeding cereal crops that might have resulted in increase in plant height. Second year of the experiment produced taller plants which might be the carry over and accumulative effects of nutrients release from legumes decomposition after a year time.

Biological yield

Biological yield (t ha⁻¹) of canola was significantly affected by C, GM, AGM and N levels (Table 2). The interactions between C x GM and C x AGM x N were also found significant for biological yield. Mean values indicated that guar sown as green manuring preceding crop produced maximum biological yield (10.564 t ha⁻¹) of canola as compare to millet sown plots (9.418 t ha⁻¹). These results are in line with those of [38]

who reported that legumes crop residues have higher nitrogen contents having narrow C: N ratios. This lower C: N ratio helps in faster decomposition than the cereals residues. Data further suggested that whole plants incorporated plots had produced maximum biological yield (10.179 t ha^{-1}) of canola as compare to plots where only stubbles were incorporated (9.818 t ha^{-1}). These results are in line with those reported by [39] who stated that green manuring of crop into the soil resulted in the improvement of soil physical, chemical and biological properties which lead to the increase in canola yield. Green manuring at 40 DAS had produced maximum biological yield (10.481 t ha^{-1}) followed by 70 DAS (10.369 t ha^{-1}) while the lowest biological yield (9.147 t ha^{-1}) was recorded in plots green mannured at 100 DAS. Biological yield increased with the increase in N levels as maximum biological yield (11.2 t ha^{-1}) was recorded at 100 kg N ha^{-1} while minimum biological yield of 8.287 t ha^{-1} was recorded in control plots. The possible reason for the increase in biological yield with the increase level of N is that N increases the vegetative growth resulting in more photosynthates, which increase the growth and development of the crop and thus resulted in the increase in biological yield. Other reason for this might be that crop growth rate and duration of the growth both indicate the potential for improvement in the yield. It is perhaps related to accelerating the photosynthesis activity and the activities of photosynthesizing tissues during the growth period [40]. These results are in line with the findings of [41, 13, 42,

24] who reported similar trend of increasing biological yield with the increase in N rates. Significantly higher biological yield was recorded in the second year of the experiment as compared with the first year. The probable reason for this could be residual N during the second year of the experiment.

The interaction between C x GM (Fig. 5) showed that whole plants incorporation in guar sown plots enhanced biological yield of canola. Millet sown as a preceding green manuring crop had lower biological yield as compared with guar. The interaction for C x AGM x N (Fig. 6) suggested a linear increase in biological yield of canola with the increase in N levels in both guar and millet sown plots. Green manuring at 40 DAS leveled off after 75 kg N ha^{-1} in case of millet while it increased up to 100 kg N ha^{-1} when guar was incorporated at 40 DAS. Significantly higher biological yield of 11.875 t ha^{-1} was recorded in 2nd year as compared with 1st year (8.1 t ha^{-1}) of the experiment. Similar results were reported by [38] who stated that legumes crop residues have higher nitrogen contents resulting in faster decomposition than the cereals residues resulting in more availability of N to the plant that increased the yield and yield components of winter oilseed. Further, [39, 43] found that crop residues incorporation into the soil acts as a source of mineral elements that can sustain plant growth and boost the activities of soil microorganisms, provide an ideal condition for canola growth resulting not only yield increase but also reduces the N requirement of canola.

Table 2. Emergence m², Leaf area plant⁻¹, days to maturity, plant height (cm) and biological yield of canola as influenced by green manuring crops, its incorporation and age at green manuring under varying nitrogen levels.

	Emergence (m²)	Leaf area plant⁻¹	Days to maturity	Plant height (cm)	Biological yield (t ha⁻¹)
Green manuring Crops (C)					
Millet	93	1456 b	178	142 b	9.418 b
Guar	98	1777 a	179	153 a	10.564 a
Significance level	ns	**	ns	**	**
Green Manuring (GM)					
whole plants	94	1644 a	179 a	149	10.179 a
stubbles only	97	1593 b	178 b	146	9.818 b
Significance level	ns	**	**	ns	**
Age at green manuring AGM (Days)					
40	94	1483 c	179	148 a	10.481 a
70	99	1768 a	179	152 a	10.369 a
100	93	1605 b	178	143 b	9.147 b
LSD _(0.05)	ns	74	ns	4.9	0.572
Nitrogen levels (N) kg ha⁻¹					
0	94	1507 c	178 b	141 b	8.287 c
75	96	1606 b	179 ab	151 a	10.463 b
100	96	1744 a	179 a	151 a	11.246 a
LSD _(0.05)	ns	32	0.6	3.8	0.343
Year Means					
2011-12	89	1539	173b	134b	8.123b
2012-13	101	1699	184a	161a	11.875a
Interactions					
AGM x C	ns	** Fig. 3	ns	** Fig. 6	ns
GM x N	ns	ns	ns	ns	ns
AGM x GM	ns	ns	ns	ns	ns
AGM x N	ns	ns	ns	ns	ns
AGM x GM x N	ns	ns	ns	ns	ns
C x GM	ns	ns	ns	ns	** Fig. 7
C x N	ns	ns	ns	ns	ns
C x GM x N	ns	** Fig. 4	ns	ns	ns
AGM x C x GM	ns	ns	ns	ns	ns
C x AGM x N	ns	* Fig 5	ns	ns	** Fig. 8
AGMxCxGMxN	ns	ns	ns	ns	ns

Means of the same category followed by different latter are significantly different from one another at 5% and 1% level of probability. Where *,** = Significant at 5 and 1% level of probability, respectively.
ns = non-significant

Fig. 1. Interaction between AGM x C for leaf area (cm²) of canola

Fig. 2. Interaction between C x GM x N for leaf area (cm²) of canola

Fig. 3. Interaction between C x AGM x N for leaf area (cm²) of canola

Fig. 4. Interaction between AGM x C for plant height (cm) of canola

Fig. 5. Interaction between C x GM for biological yield (t ha⁻¹) of canola

Fig. 6. Interaction between C x AGM x N for biological yield (t ha⁻¹) of canola

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