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Plant spacing - a non polluting tool for aphid (Hemiptera: Aphididae) management in canola, *Brassica napus*

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Abstract

Current study was initiated to generate the information on the effect of row-to-row distance of brassica crop, *Brassica napus* L., on aphids population. Three line spacing (20, 30 and 40 cm) with a constant nine cm plant to plant distance were evaluated on aphids infestation and its impact on seed yield. The collected and edited data on fixed parameters indicated that an inverse relation was found between increased line spacing and aphids population. It was evident that the mustard aphid, *Lipaphis erysimi* (Kaltenbach), population increased significantly as the inter row spacing decreased. Distance of 30 cm was quite respondent towards holding aphids number and grain yield, where optimum number of aphids (103.00 per plant) was recorded with maximum yield (980.00 Kg/Hectare). Maximum mean aphids number (163.5) was observed on the plants spaced at 20 cm apart rows with minimum seed yield (683.20 Kg). Minimum mean number of aphids (63.3) was recorded from the lines grown at the distance of 40 cm from each other with 783.20 Kg yield. The information accruing from this study showed that in areas where aphids problem is endemic, narrow rows spacing would tend to increase aphids population. Therefore, the row-to-row spacing not less than 30 cm with nine cm plant-to-plant distance is recommended in oleiferous brassica especially canola crop, as a component of integrated pest management tool to culturally control of aphids.

Key words: aphids, *Brassica*, infestation, plant spacing, cultural control

چکیده

تحقیق حاضر برای به دست آوردن اطلاعاتی از تأثیر فاصله‌ی بین ردیفی گیاه *Brassica napus* L. روی جمعیت شته‌ها آغاز شد. سه فاصله‌ی خطی (۲۰، ۳۰ و ۴۰ سانتی‌متری)، با فاصله‌ی ثابت نه سانتی‌متر بین هر گیاه، روی آلودگی شته و تأثیرش روی محصول دانه ارزیابی شد. اطلاعات جمع‌آوری و تصحیح شده روی پارامترهای ثابت نشان داد که افزایش فاصله‌ی خطها با جمعیت شته رابطه‌ی معکوس دارد. با کاهش فاصله‌ی داخلی ردیف‌ها، افزایش معنی‌دار جمعیت شته‌ی خردل، *Lipaphis erysimi* (Kaltenbach)، مشهود بود. جایی که تعداد اپتیمم شته (۱۰۳/۰۰ شته در گیاه) با بیشترین میزان محصول (۹۸۰/۰۰ کیلوگرم در هکتار) ثبت شد، فاصله‌ی ۳۰ سانتی‌متری کاملاً جواب‌گوی نگه‌داری این تعداد شته و محصول دانه بود. بیشترین میانگین تعداد شته (۱۶۳/۵) روی گیاهانی با فاصله‌ی ردیفی ۲۰ سانتی‌متر از هم و با کمترین محصول دانه (۶۸۳/۲۰ کیلوگرم) مشاهده شد. کم‌ترین میانگین تعداد شته (۶۳/۳) برای گیاهانی با فاصله‌ی ردیفی ۴۰ سانتی‌متر از هم و میزان محصول ۷۸۳/۲۰ کیلوگرم ثبت گردید. اطلاعات حاصل از این پژوهش نشان داد که در مناطقی که مشکل شته‌ها یک مشکل بومی است، فاصله‌ی کم ردیف‌ها منجر به افزایش جمعیت شته‌ها خواهد شد. بنابراین، فاصله‌ی بین ردیفی حداقل ۳۰ سانتی‌متر با فاصله‌ی نه سانتی‌متری بین هر گیاه برای چلیپاییان دانه روغنی، به ویژه کلزا، به عنوان یک جزء از ابزار مدیریت انبوهی آفات در کنترل زراعی شته‌ها توصیه می‌شود.

واژگان کلیدی: شته‌ها، چلیپاییان، آلودگی، فاصله‌ی بین گیاه، کنترل زراعی

Introduction

Aphids feeding results in both quantitative and qualitative yield losses in crops, moreover aphid transmitted viruses are responsible for other quantitative and qualitative damages, so, direct or indirect effects of aphid infestation are always of interest. In addition to direct damage from feeding on plants, aphids can transmit toxins which have an adverse effect on yield and grain quality parameters such as protein content (Zsuzsa & Adrien, 2003). Basky *et al.* (2006) suggested that aphid infestation may have an adverse effect on quality of flour. Aphid infestation had greatest decreased effect on glutenin and gliadin contents, total protein content and gliadin/glutenin ratio.

Cultural methods of insect control comprising the regular farm operations to destroy the insects or to prevent them from causing injury to the crops, have been used as preventive measures against insect pests. For the achievement of cultural control, the phenomenon of plant spacing has been remained as focal point by certain entomologists. Avasthy & Varma (1979) showed that in areas where shoot borer, *Chilo infuscatellus* Snellen, is problem, narrow row spacing would tend to increase shoot borer damage in sugarcane crop. Katanyukul *et al.* (1979) reported that rice planted at high seedling density had higher percentage of damaged tillers by gall midge, *Orseolia oryzae* (Wood-Mason). Kushwaha & Sharma (1981) determined that plant spacing had more influence on the pest incidence and was inversely proportional to the incidence. Bhutto *et al.* (1997) indicated that stem borer, *Scirpophaga incertulas* (Walker), infestation varied significantly with seedlings density and spacing in rice. Malik *et al*. (2003) evaluated the effect of row to row distance of onion plants on thrips (*Thrips* spp.) population; an inverse relation was found between increased line spacing and thrips population.

Practically no specific work has been reported to check the aphid's infestation in the rape and mustard crops by adopting different inter row spacing. Only Prasad (1979) while conducted trial to find out the efficacy of systemic granular insecticides against the mustard aphid, *Lipaphis erysimi* (Kaltenbach), on rapeseed crop, observed that rapeseed yield might be lower due the distant spacing (75 cm) of the rows. Though, this pest can be controlled by insecticide spraying, but the indiscriminate use of chemicals have created many problems like infamous three viz., resurgence, resistance and residue aspects besides the health hazardous. The contained application of insecticides has enhanced the potential for development of secondary insect pests. An effective way to insecticides resistance management and still to maintain insect population densities below the economic threshold is to reduce the use of pesticides with the integration of other control strategies. As the recommendations of the modern technology of pest control, emphasize economical and ecological considerations prior to pests management, the present investigation was under taken to manage this one of the most nefarious biotic constraints of rapeseed and mustard by the use of cultural practice.

Plant varieties with improved attributes are not always sufficient to reach self-sufficiency in food. Management practices such as optimization of plant density are equally important as additional different agronomic characters for pest management. The purpose of this article is to consider the best possible role of alternative for aphid management and to study the potential of plant spacing as a non-pesticide tactic on eco-friend lines. By considering these facts, the present investigation attempt has been initiated to assess out optimum plant population requirements amongst rape and mustard crops for aphid management.

Materials and methods

Field studies were aimed to study the activity of aphid pest and evaluation of suitable plant spacing to keep it at a minimum level successfully. Present experiment was laid out at a piece of land owned by the Nuclear Institute of Agriculture, Tandojam, Pakistan. Crop (canola, *Brassica napus* L., variety “Dunkeld”) was sown in experimental plots each measuring 2.5 m^2 in size separately, by dividing the total area into nine different subplots. There were three replications of each treatment within three subplots in a randomized block design. For the evaluation of inter row spacing (row to row distance) effect on aphids population, three treatments of row distance (T1 = 20, T2 = 30 and T3 = 40 cm) having a constant of nine cm plant to plant spacing, were maintained on the well prepared land. The crop was planted in four rows within each 1×2.5 m^2 plot, each plot separated by one m from other. No any line spacing replications were sprayed with insecticides. Observations were recorded on aphids population and grain yield of each treatment. Since, aphids infestation starts later at blooming growth stage of the crop, observations on pest incidence were recorded 12 weeks after sowing because the pest appeared in the field much late. Sample size was 2.5 m row length, where population counts of aphids (nymphs, winged and wingless adults) were recorded from 5 random plants from each treatment plot. For recording observations, the whole plant surface within sampling unit was examined thoroughly at leaves and inflorescences. The weekly observations were taken by counting aphids numbers from entire leaves and terminal shoot on per plant basis starting from the first appearance of aphid till the population become negligible or ceased. The observations on aphid population were taken per five randomly selected plants in each replicate. As the weeds can play the possible role as the alternate hosts for this insect pest, hand weeding was done four times throughout the season to keep the whole experimental plot free of weeds. Crop was irrigated three times at different intervals.

To yield excellent results of grain produce, locally recommended agricultural practices were followed for raising crop. Fertilizers were applied in soil in split doses at the time of sowing and at flowering initiation to be proved highly effective and to afford very good crop stand. A combination of 100 kg N, 75 kg P and 30 kg K per ha was the optimum dose rate used in terms of good canola grain production. At crop maturity, data on seed yield obtained after harvesting from different plots were weighed and yield was calculated. After obtaining the yield of each treatment, the responses of aphids infestation on the produce of different line spacing were compared. To test the differences between both the variables (aphids and yield), an analysis of variance was constructed and "least significance difference test" was applied to differentiate the means by using computer programming. The significant differences were determined by one-way analysis of variance. The significance levels were compared using computer soft ware (SPSS, 2005) reported at $P = 0.05$.

Results and discussion

Overall field observations of the trial conducted indicated that during the growing season, aphid infestation originated in the field nearly 10 weeks after crop germination. Therefore, the crop in all treatment plots escaped much of damage during early growth stage and during this period the crop growth and stand were satisfactory. Taking a note of this behaviour, crop protection against this pest at earlier stage may not be considered essential. Aphids population and line spacing data portrayed in table 1, demonstrated that among three row spacing used as treatments for this study, statistically significant differences existed between experimental sets for aphids infestation level. However, at the end of experiment at crop maturity, infestation levels fallen considerably in all treatments.

- Aphid and plant population

During the present study, mustard aphid, *L. erysimi*, was the most frequently occurring pest in crop. Significant differences between pest (aphids) populations at different line spacing showed that inter row spacing has inverse relation with aphids density. Increase in line spacing in all the treatments proved to have a negative effect on aphids density, in contrary to that decreased line spacing encouraged its multiplication. Results revealed that mean aphids infestation was significantly the highest (163.5 aphids/plant) when rows were spaced at 20 cm. The least aphids population (63.3 aphids/plant) was recorded significantly when rows spaced at 40 cm. Similarly, optimum number of aphids (103.00) was recorded on plant cultivated in 30 cm spaced lines (table 1).

These findings suggest that aphids responded differently to rows and plant population. This could happen, when the variety with better genetic background experienced different microenvironment fluctuations in crop canopy, being induced by row spacing. The information accruing from the present study showed that in areas where aphids problem is endemic, narrow spacing of rows would tend to increase damage in this crop. These observations acquired can be explained by assuming that in lower plant density (40 cm) aphids were unable to travel easily from one site to the another, further thinner plant canopy lacked sufficient coverage; on the other hand on dense plant population (20 cm) aphids were able to easily and safely travel from the base of the plant to the top, and from plant to plant. Dense canopy also facilitated the possible site for oviposition and the sufficient plant coverage harbored maximum insect population to render peak multiplication, and thus invariable population and yield strengths resulted on different row spacing. This generally did not happen in 30 cm line spacing because plants in there lacked appropriate coverage but were vigorous enough to tolerate the damage and recovered rapidly by producing healthy pods.

Table 1. Effect of plant spacing on aphids population and seed yield.

S. No.	Row to row distance	Aphids population/ plant	Yield/plot ($2.5\ m^2$) (gm)	Yield Kg/Hectare
1.	T1= 20 cm	163.5 ± 17.32	170.80 ± 11.54	683.20
2.	T2= 30 cm	103.00 ± 17.32	245.00 ± 25.98	980.00
3.	T3= 40 cm	63.30 ± 5.77	195.8 ± 17.32	783.20

ANOVA

		Sum of squares	df	Mean square	F	Sig.
Replication	Between Groups	0.000	2	0.000	0.000	1.000
	Within Groups	6.000	6	1.000		
	Total	6.000	8			
Aphid	Between Groups	15276.380	2	7638.190	12.060	0.008
	Within Groups	3800.000	6	633.333		
	Total	19076.380	8			
Yield	Between Groups	8551.280	2	4275.640	3.858	0.084
	Within Groups	6650.000	6	1108.333		
	Total	15201.280	8			

Presently, *L. erysimi* has been found to be active before flowering initiation stage of growth attaining its peak at the flowering stage. This suggested that in order to nip the population build of the pest on the flower buds, the control operations should also be taken for clean cultivation as the adjoining grasses can harbour this pest in the off season or probably may act as alternate hosts in the absence of the major crops, so that aphid intensity of attack on main crops is reduced.

- Grain yield and plant population

The analytical results obtained after experimentation indicated that with the mean increase in total number of aphids per plant the grain yield was dwindled down. The yield (245.00 gm/2.5 m^2 plot) (980.00 Kg/Hectare) gained by 30 cm line to line spacing was significantly quite respondent, where the highest yield was recorded. This yield parameter at maximum level was due to less competition among crop plants for nutrients, moisture, light and space for survival, i.e. crop plants fully utilized the available resources. Further, optimum plant population had gradually and significantly decreased the number of aphids populations and the highest yield was achieved.

Closer inter row spacing had produced significantly poor yield than wider spacing. Significantly, the least grain weight (170.80 gm/2.5 m^2 plot) (683.20 Kg/Hectare) was gained in case of 20 cm line distance. This can be attributed due to fact that densely cropped plant rendered maximum shelter, breeding and roosting sites for aphids development. Owing to the very high population of aphid, the developing pods did not produce healthy seeds and yield of severely infested crop was reduced. Decrease in row spacing (20 cm) resulted in considerably severe competition among aphids for food, shelter, and among plants for nutrients and water that resulted in poor growth and decrease yield. The lower yield with higher aphids populations could be explained due to two reasons: (1) higher aphid populations itself had negative effect upon yield due to excessive plant de-sapping and (2) higher plant populations might be disturbed physiological process with micro-climate changes of the crop canopy being created by their own stands.

Subsequent observations revealed that yield was considerably moderate (195.8 gm/2.5 m^2 plot) (783.20 Kg) when 40 cm line to line distance was provided. The moderate yield due to lower plant populations could be explained as the effects of lower competition for nutrients and moisture among crop plants. This lower seed yield in contrary to optimum plant density can also be attributed due to less numbers of plants per unit area. These experimental results demonstrated that the reduction in grain yield was due to greater insect damage as will as unfortunate or deprived plant population. These findings are quite in agreement with the observations of Singh & Yadava (1972), where it was found that in *Brassica campestris* var. *toria*, row spacing of 30 cm was significantly better for best yield potential, while rows of 45 cm and 60 cm apart did not differ from each other. It also corresponds to the study of Hamid *et al.* (1993) where inter row spacing of 30 and 40 cm apart showed significantly better performance than 50 cm apart in oilseed crops for optimal produce. But are in contradictory to those of Kondra (1975) who reported that narrow row spacing of 15 cm in spring oilseed rape resulted in the highest yield compared with the row spacing of 23, 31 and 61 cm. Munir & Neilly (1992) recorded no significant differences for seed yield and its components due to row spacing of 15 and 7.5 cm. These variations in yield among oilseed rape might be due to difference in genetic potential of the variety and environment.

The adoption of 30 cm row spacing has superfluous advantages. Honek's (1983) study showed that plant density considerably affected predator abundance, which may have been due to microclimatic differences between stands. The *Coccinella* species were negatively influenced by increases in plant density and the syrphids preferred dense stands. Dosdall *et al.* (1999) determined that increasing seeding rates and row spacing is a practice that is compatible with reducing crop damage from important canola pests. Alpaslan *et al.* (2001) studied the protein content that was significantly influenced by row space and 70 cm row space had the highest protein content followed by 60, 50, and 40 cm in oilseed. Mujtaba *et al.* (2003) conducted an experiment to study the impact of row spacing (15, 30, 45 and 60 cm) on canola. The highest yield and yield components were observed from plots where row spacing was kept at 45 cm. Pandey *et al.* (2004) conducted an experiment to study the effect of row spacing practice (30 and 60 cm) on weed growth and productivity of oilseed (soybean). The highest weed control efficiency and grain yield were recorded in narrow row spacing (30 cm) as compared to wider row spacing (60 cm). Asiwe *et al.* (2005) measured severity of aphid infestation that increased with increase in plant spacing. With this cultural operation in spite of natural regulation of aphids, its population sometimes can explode above economic threshold level or beyond the range of control. Bakhetia & Sekhon (1991) reported that owing to their high reproductive rate, 50 aphids per 110 cm shoot, is economic threshold level for the mustard aphid. By keeping this as an index, aphidophagous insects, plant products or chemical insecticides treatment could be given in combination or alone just before the aphids population attained economic threshold level. Other important pest management practices should also be considered, because detailed study of the basic biological parameters affecting the population development of aphid resulted that the newly hatched nymphs were highly active in searching for feeding places, and ten aphid generations were recorded during one crop growing season (Iversen & Harding, 2007). While, using toxicants, extreme care should be taken for the selection of chemicals because one of the main problems of seed production in canola is pollination and fertilization of flowers and insects are the major pollinators (Pordel *et al.*, 2007). Nevertheless, current efforts to reduce pesticide use in agriculture may promote broader adoption of cultural control strategies for pests management in canola (Lloyd *et al.*, 2002).

Since, Pakistan is facing a chronic shortage of vegetable oil and her farming community is keenly interested to harvest high output, a distance of 30 cm inter row spacing with 9 cm plant to plant distance can be recommended for commercial oil production, but it is imperative that this should not be less than 30 cm. Therefore, it could be inferred that optimum plant spacing can help in reducing aphids infestation in oilseed brassica crop. This strategy we developed is of utmost importance to maintain aphid abundance at decrease level but it should be adopted as potentially and supplementary tactic to develop a functional integrated pest management package. This intervention claimed would be a big economical motivation for the growers and creative opportunity for researchers to ensure the sustainable returns in existing scenario of oilseed production.

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