Effect of Green Manure, *Sesbania bispinosa* Wight Amendment on Incidence of Sucking Insect Pests, their Predators and Yield in Organic Cotton

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Abstract: Cotton holds the key importance in the economy of Pakistan, but its yield is severely affected due to the infestation of many insect pests. Farmers mostly rely on chemicals to control pests but their adverse effects on human health and their interests are also considerable. Therefore, this study was conducted over two years to evaluate the influence of amendment of soil with green manure (GM) Dhancha, *Sesbania bispinosa* Wight on the population of cotton sucking insect pests and their predators. Significant impact of GM was found in lowering the population of sucking pests of cotton i.e., *Thrips tabaci* (Lind), *Bemisia tabaci* (Gennadus), *Amrasca bigutulla bigutulla* (Ishida) and *Tetranychus urticae* (Koch) during both years. Population of predators i.e., *Chrysoperla carnea, Geocoris punctipes* and *Orius* sp. was also higher in dhancha treated plots in comparison to control. Application of neem oil was found effective in lowering the population of sucking insect pests during 2014; whereas, application of *C. carnea* cards showed significant impact after the mid cotton season during 2015. Overall growth and yield parameters were better in dhancha amended organic cotton treatment in comparison to control.

Keywords: Cotton, dhancha, green manure, pests, predators, yield.

INTRODUCTION

Cotton, *Gossypium hirsutum*, is a key to economic growth of Pakistan. Its contributed share in GDP is 1.5% along with 7.1% share in value added agriculture goods. Cropping area under cotton cultivation has increased at 5.5% from 2,805,700 in 2013-14 to 2,961,000 hectares in 2014-15 that produced 13.983 million bales. There was a rise of 9.5% in comparison to 2013-14 yield of 12.769 million bales. Such high production of cotton has brought a worth of US$ 10.22 billion foreign exchange to Pakistan [1]. Although, cotton production has shown increasing trends during recent years, but per hectare yield is still low as compared to competing countries. Insect pests of cotton are the major constraints to profitable cotton cultivation throughout the world and their impact particularly in developing countries like Pakistan is still aggravated [2]. Although cotton is not a food crop, about 60% of cotton production is seed that is further processed to get edible oil. It is also used to manufacture cattle feed, and enter into human food chain [3].

About 162 species of insects have been reported as pests of cotton that deteriorated the yield either by direct sucking sap from leaves or by damaging bolls and other cotton parts [4]. Farmers mostly rely on chemical control strategies to control insect pests of cotton; however, they still lose 29% of their potential yield [5]. Moreover, chemicals used in cotton against pests have many adverse impacts to human and their interests. It is estimated that annually about 10,000 farmers and field workers are poisoned by pesticides in Pakistan [6]. Indiscriminate use of chemical has severely affected the natural enemy populations in agro ecosystem and the populations of natural enemies of insect pests have declined up to 90% in cotton growing areas of the country [7].

Organic agriculture is defined as a farming system, where the use of synthetic chemical i.e., pesticides and fertilizers is prohibited. Such systems mainly depend the practices of crop rotations, nitrogen fixation through natural resources, biologically active soil, use of recycled farm manure or crop residue, and control of pests by using biological or mechanical controls [8, 9]. Organic farming is more environment friendly than conventional intensive farming that heavily depends on the synthetic pesticides and fertilizers to get higher crop production. Recent researches have suggested that organic farming results in higher carbon storage and less leaching of nutrients available to plants [10] and lower the level of pesticides in water systems [11]. Organic agriculture increases biodiversity [12, 13]. Wyss *et al.* [14] proposed a model of pest management for organic crop production involving cultural methods

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that are well-suited with the natural practices of crop rotation and soil and vegetation management to enhance the impact of natural enemies either by inundating or inoculating the release of natural enemies along with using approved insecticides of biological origin and mating disruption [15]. Several studies have found comparatively less number of pests in organically grown crops in comparison to crop grown by using synthetic chemicals [16-18].

Organic farming is practiced in more than 170 countries on more than 43.1 million hectares with market value of 72 billion USD. This represents less than 1% of total agriculture area of these countries [15]. Social benefits of cotton organic farming include decrease in exposure to harmful agrochemicals and increased income security [19]. The Textile Exchange Organic Cotton Farm and Fiber Report [20] said that about 27.2 million metric tons of organic cotton was cultivated on 35.7 hectares in 2012, which equals 0.7 percent of global agricultural area. Organic cotton is grown in many countries worldwide led by India [21]. In conventional cotton, Pakistan ranked fourth [22], but in organic cotton, Pakistan is not listed in first top ten producers that indicates the lack of knowledge about cultivation of organic cotton in Pakistan.

In recent years, many growers have shifted their cotton cultivation practices towards more eco-friendly practices, where application of green manures is of key importance. A green manure (GM) is a crop pulverized into soil for nutrient enrichment and modification of soil in the succeeding crops to improve the economic viability and reduce adverse environmental impacts [23]. Significant effect of application of green manures has been reported on growth and yield parameters of cotton in many countries of the world [24-27]. The slow release of nitrogen through decomposition of green manure residues may be better matched with its uptake by the plant according to its requirement that the inorganic nitrogen, resulting in efficient N-uptake and improved crop yield with least leaching of nitrogen [28, 29]. Application of GM can also result in the permanent improvement in organic matter of soil and microbial biomass [30-32], further improving nutrient retention and N-uptake efficiency. Application of green manure may reduce soil erosion [33], reduce nutrient or pesticide losses [34, 35], and can lower the pest population and support higher natural enemy populations [36-39]. Therefore, keeping in view the significance of insect sucking pests to cotton, adverse effects of chemicals, significance of *C. carnea* against sucking pests and potential of green manures to improve and maintain soil fertility as a source of organic fertilizer for cultivation of cotton , a two year comprehensive study was conducted to evaluate the effect of application of green manure using dhancha (*Sesbania bispinosa* Wight) and *C. carnea* cards for pest management and predator populations in cotton and their ultimate impact on cotton growth and yield parameters.

MATERIALS AND METHODS

Study Location and Experimental Design

The study was conducted at Latif Experimental Farm, Sindh Agriculture University Tandojam, and Sindh during cropping seasons 2013-14 and 2014-2015. A Randomized Complete Block Design (RCBD) with four replications was used for the experiment. The experiment comprised of two treatments: green manure and control. The treatment plot size was 40x50 sq. meters and the replication plot size was 10x50 sq. meter. The type of soil used in the study was clay loam with good texture.

Cultivation of Green Manure, Dhancha (*Sesbania bispinosa* Wight) and Cotton

Dhancha, *Sesbania bispinosa* Wight was cultivated and cultured as Green Manure (GM) in first week of April. All applicable agronomic practices were applied as per practice. After week five, standing crop was pulverized and mixed in soil.

Cotton variety (Sindh-1) was planted on May 15, 2014 and May 8 2015 by dibbling method on furrows in both GM and control treatments plots. The distance between plant to plant and row to row was 22.5 cm and 75cms, respectively. Weeding and inter-culturing in the crop was carried out manually one month after germination of the crop. Subsequent weeding was carried out after a time interval of one or two months depending upon weed growth. First irrigation was given one month after sowing, while, subsequent irrigations were applied at 10-15 days interval depending upon requirement of the crop.

Application of Neem Oil and *Chrysoperla carnea* Stephens Egg Cards

In GM treatment plots, when pest population increased and reached the economic injury level, Neem, *Azadirchita indica* A. oil was applied at fortnightly interval to keep pest populations below economic threshold levels during 2014. The neem oil

was applied at the rate of one liter per acre. The Surf® detergent was added @ 5 grams per spray tank to emulsify the spray solution. During 2015 crop, *C. carnea* cards were used @ 5 cards acre^{-1} at fortnightly intervals as an integrated pest management intervention to control the sucking insect pests. *Chrysoperla carnea* cards were provided by the Nuclear Institute of Agriculture (NIA), Tandojam. The cards were hanged randomly in the middle of cotton plants.

Data Collection

Sucking Insect Pests and their Predators

Observations on the population of pests and predators were initiated forty days after planting of cotton crop and continued till harvest of cotton at weekly intervals. The data were taken from the plants selected at random (tagged) to check the pest population fluctuation of sucking insect pests in the field. The data were taken in the morning at 8. 30 AM. Observations on sucking complex such as thrips *Thrips tabaci* (Lind), whitefly *Bemisia tabaci* (Gennadus), jassids *Amrasca bigutulla bigutulla* (Ishida) were recorded from five plants per treatment, selected randomly. From each plant, data was collected from one leaf from top, two leaves from middle and two leaves from bottom portion (total five leaves / plant). Both immature and adult insects were recorded for all sucking insect pests. The predator population was recorded from five plants selected at random and whole plant was thoroughly observed for presence of natural enemies. Population of both nymphs and adult predators was recorded.

Yield Parameters

Plant Height

Height of five randomly selected cotton plants was recorded from each replication, resulting in 20 plants treatment^{-1}. The first observation was taken 60 days after sowing and second after 100 days of sowing of cotton crop. The plant height was measured in centimeters.

Crop Maturity and Yield

The opening of cotton bolls was considered as the maturity of crop. First observation was recorded in the 4th week of August and second in the 3rd week of September. The data on total and opened bolls were taken and percent open bolls were calculated. The data were collected from twenty five plants selected at random from each treatment plot. First picking was done when more than 50% bolls of cotton were open. Two pickings were done and yield per treatment was recorded.

Data Analysis

All collected data was analyzed using Two-way Analysis of Variance, whereas means with significant difference were separated using Least Square Difference (LSD). Statistical software SAS 9.4 was used to analyze all the collected data.

RESULTS AND DISCUSSION

Population Fluctuation of Sucking Pests

Results on the population fluctuation of different sucking insect pests showed great variation in dhancha treatment during 2014 in comparison to control. Comparatively higher populations of sucking pests were recorded in control as compared to dhancha. Moreover, a sudden rise in the population of *T. tabaci* was recorded at the middle of the cotton season, which remained high till the harvesting of cotton. Significant effect of application of neem oil spray was recorded on the population of different sucking pests as reduction in population of pests was recorded during 2014. Significantly higher ($F=7.82$, $DF=1$, $P<0.011$) population of *T. tabaci* was recorded in control as compared to dhancha. Moreover, significantly higher ($F=4.51$, $DF=1$, $P<0.043$) population of *B. tabaci* was also recorded in control as compared to dhancha treatment (Figure **1**). No significant difference was recorded between dhancha and control with respect to population of *A. bigutulla bigutulla* ($F=0.49$, $DF = 1$, $P<.4901$) and *T. urticae* ($F=0.11$, $DF=1$, $P<0.7447$).

During 2015, except *T. tabaci* population of remaining pests fluctuated comparatively less and remained low in both dhancha and control treatments. However, population of *B. tabaci* showed a sharp increase at the flowering time of cotton, remained at higher densities during the middle growth period of cotton and declined at the end of season in both treatments. Moreover, application of *C. carnea* cards did not show any affect in reducing the pest population during the initial growth period of cotton as population of all pests especially *T. tabaci* tended to show an increasing trend. However, significant influence of application of *C. carnea* cards was observed after the middle growth period of cotton as population of *C. carnea* started to establish in the field. No significant difference was recorded in the population of *T. tabaci*

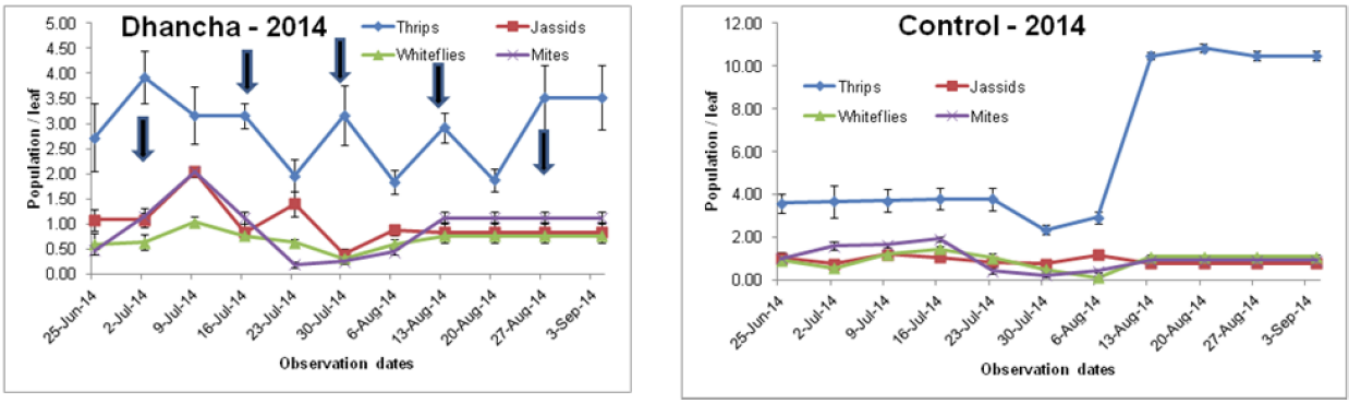

Figure 1: Mean±SE population fluctuation of different sucking insect pests of cotton per leaf during 2014. Vertical arrows show timings of application of Neem oil.

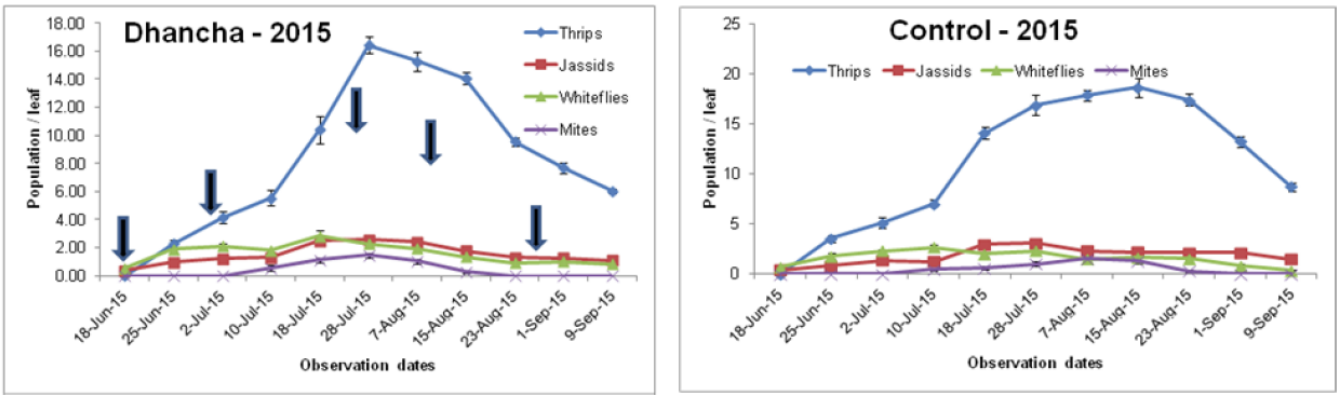

Figure 2: Mean±SE population fluctuation of different sucking insect pests of cotton per leaf during 2015. Vertical arrows show timings of application of *C. carnea* cards.

(F=1.23, DF=1, P<0.2810), *B. tabaci* (F=0.23, DF=1, P<0.6341), *A. bigutulla bigutulla* (F=0.83, DF=1, P<0.3724) and *T. urticae* (F=0.07, DF=1, P<0.7997) between control and dhancha treatments (Figure **2**).

Population of *T. tabaci* was comparatively higher than other pests; therefore, application of neem oil was made to reduce pest population. Application of neem oil was effective in reducing thrips but it needed repetitive applications because of pest population resurgence. Population development of *B. tabaci, A. b. bigutella* and *T. urticae* was comparatively less severe in dhancha amended cotton than control mainly due to the repeated application of neem oil. Swezey *et al.* [40] compared pest population between organic and conventionally grown cotton, found Lygus bugs significantly more abundant in the organic than in the conventional fields. *Thrips tabaci* and *T. urticae* abundance were not statistically different between the organic and conventional treatments in any of the three years. Jackson [41] conducted experiments on effect of organic and conventional methods of cotton cultivation on pests and predator population and observed comparatively higher populations of *T. tabaci* in organic treated plots as compared to conventional cotton. Studies by [42, 43] have also reported that populations of *A. gossypii, B. tabaci* and *A. b. biguttula* started appearing on cotton around mid-June and peaked in August. As such, these findings support findings of our study as populations of all above mentioned sucking insect pests have been recorded with *T. tabaci* being a dominant species.

Population Fluctuation of Predators

Results on the population of predators, showed a great variation in both dhancha and control during 2014 and 2015. Comparatively, higher populations were recorded in dhancha in comparison to control (Figures **4** & **5**). Among natural enemies, only significant difference was recorded in the population of *C. carnea* (F=3.17, DF=1, P<0.0048) during 2015 where higher population of the predator was recorded in dhancha as compared to control treatment. Population of big-eyed bug, *Geocoris punctipes* (Say) (F=0.41, DF=1, P<0.6731 and F=1.80, DF=1, P<0.3660) and pirate

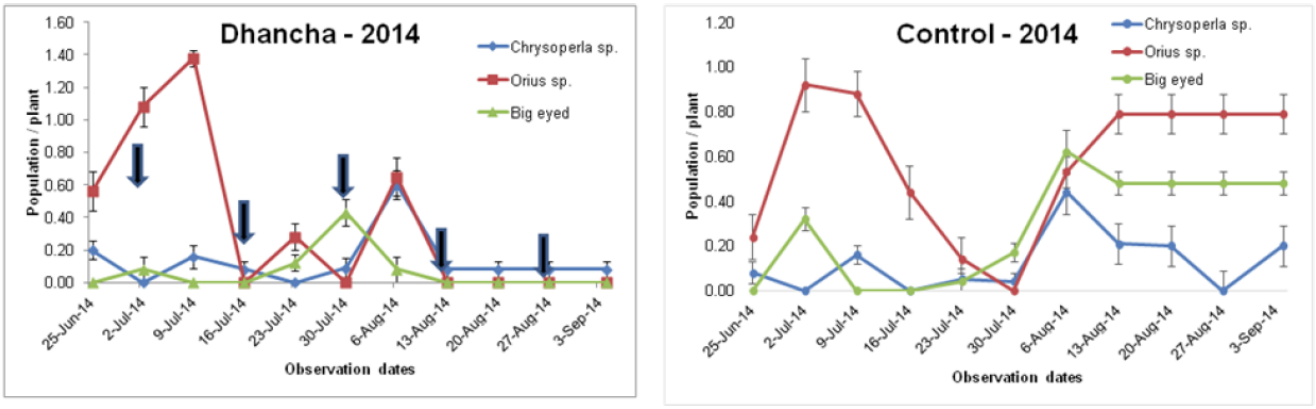

Figure 3: Mean±SE population fluctuation of different predators of sucking insect pests of cotton per plant during 2014. Vertical arrows show timings of application of Neem oil.

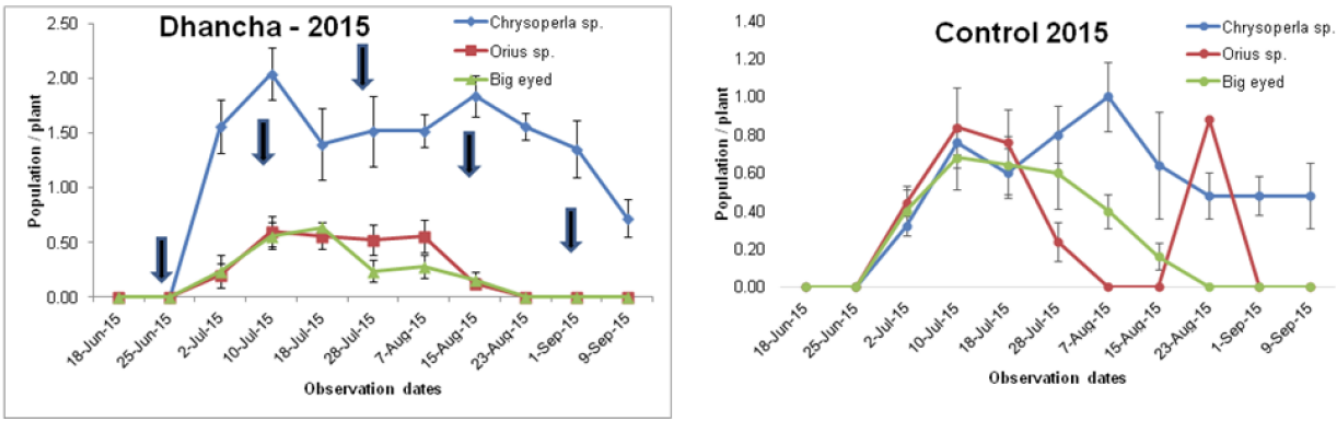

Figure 4: Mean±Se population fluctuation of different predators of sucking insect pests of cotton per plant during 2015. Vertical arrows show timings of application of *C. carnea* cards.

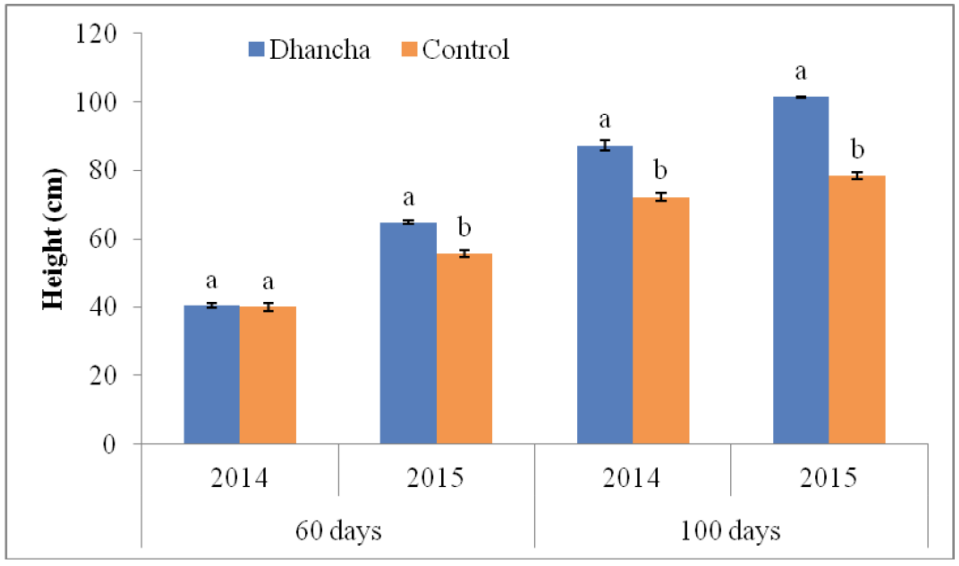

Figure 5: Effect of green manure (dhancha) on plant height (Mean±SE) of cotton during cropping seasons 2014 and 2015. Means followed by the same letters against same year are not significantly different ($P < 0.05$).

bug, *Orius* sp. ($F=1.20$, $DF=1$, $P<0.2442$ and $F=0.47$, $DF=1$, $P<0.6433$, respectively) showed no significant difference between dhancha and control treatments in both 2014 and 2015, respectively. Population of

coccinellid predators was recorded only during 2015 with no significant difference (F=0.57, DF=1, P<0.450.2) recorded in the population between dhancha (0.27±0.12 per plant) and control (0.25±0.10 per plant).

Population of natural enemies remained comparatively high in green manure amended treatment compared with control treatment. Population of *C. carnea* was higher during 2015 because this predator was released in cotton crop for population management of sucking pests. Swezey *et al.* [40] while comparing the population of predators in organic and conventional cotton, found population of predatory Lygus bugs significantly abundant in organic cotton. Jackson [41] reported higher populations of *Orius* spp., *L. lineolaris* and Lady beetles on organic cotton as compared to conventional cotton treatments. Study by [44] also reported higher populations of *G. punctipes* (Say), *Omus insidiosus* (Say) and various species of spiders in organically managed cotton compared with conventional cotton. Many previous studies have shown positive impacts of organic farming on the population of natural enemies because of no use of pesticides, better habitat for beneficial organisms due to crop rotation, greater crop diversity, and conservation of natural enemies [45-48]. Fertilizer type and concentration and herbivore feeding damage may also interact to affect foliar concentrations of phytochemical and affect insect-plant interactions [49, 50].

Plant Growth and Yield Parameters

Plant Height

There was no significant (F=0.11, DF=1, P<0.7450) effect of green manure (dhancha) on plant height during 2014, at 60 days after sowing. However, during 2015, significantly higher (F=51.84, DF=1, P<0.001) plant height was recorded at 60 days after sowing in dhancha treatment as compared to control. Moreover, significant effect of dhancha was recorded on plant height at 100 days after sowing as compared to control during 2014 (F=67.57, DF=1, P<0.001) and 2015 (F=160.28, DF=1, P<0.001) (Figure **5**).

Total No of Bolls

Data on number of bolls recorded in dhancha and control treatments are given in Figure **6**. According to results, during both years, after 100 days (F=133.63, DF=1, P<0.001 and F=334.16, DF=1, P<0.001, respectively) and 150 days (F=61.46, DF=1, P<0.001 and F=177.69, DF=1, P<0.001, respectively) of sowing, significantly higher number of bolls was recorded in dhancha treatment in comparison to control treatment.

Maturity Percentage

Results of the maturity percentage of bolls indicated that during 2014, after 100 days of sowing, significantly (F=6.30, DF=1, P<0.0365) higher maturity percentage was recorded in control as compared to dhancha treatment. No significant difference (F=0.0441, DF=1,

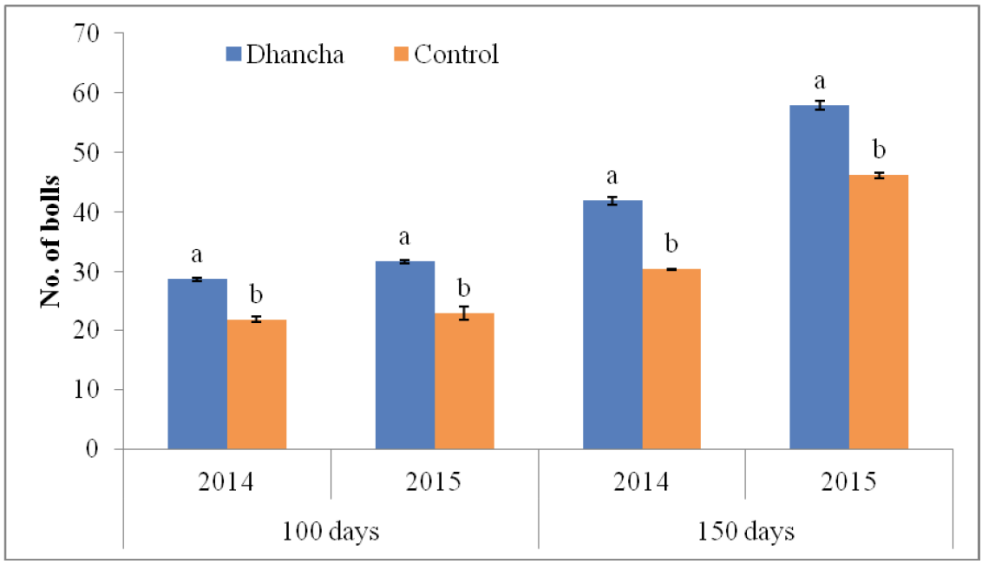

Figure 6: Effect of green manure (dhancha) on number of bolls per plant (Mean±SE) of cotton during cropping seasons 2014 and 2015.

Means followed by the same letters against same year are not significantly different (P < 0.05).

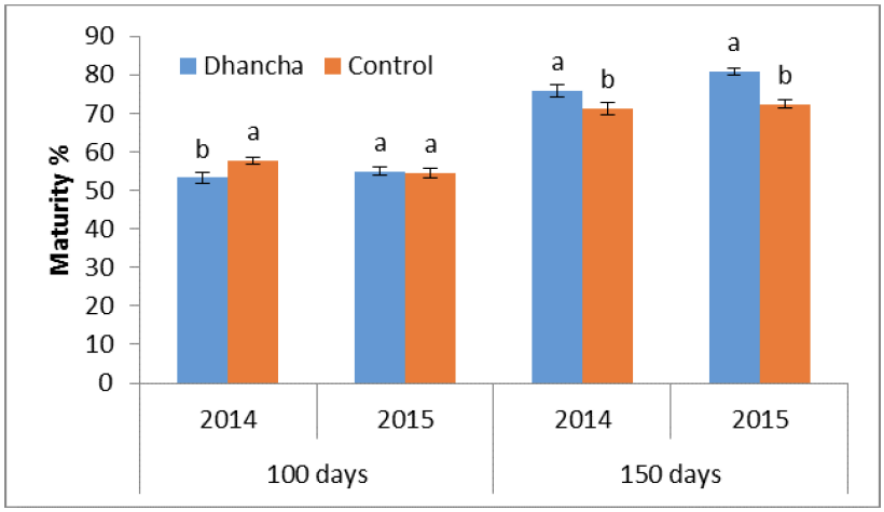

Figure 7: Effect of green manure (dhancha) on crop maturity percentage (Mean±SE) of cotton during cropping seasons 2014 and 2015.

Means followed by the same letters against same year are not significantly different (P < 0.05).

P=0.8363) was recorded between both treatments during 2015 after 100 days of sowing. However, in comparison to control, dhancha treatment showed higher (P < 0.05) maturity percentage during both 2014 (F=5.41, DF=1, P<0.0467) and 2015 (F=41.73, DF=1, P<0.0002) after 150 days of sowing (Figure **7**).

Boll Weight

Results of the boll weight showed that significantly (F=15.13, DF=1, P<0.0081) higher boll weight was recorded in dhancha treatment during 2014; whereas, there was no significant difference (F=0.85, DF=1, P<0.3931) in boll weight during 2015 (Figure **8**).

Yield

There was a significant effect of dhancha on the yield of cotton as during both years, significantly higher (F=6.35, DF=1, P<0.0342 and F=141.37, DF=1, P<0.001, respectively) yield was obtained from dhancha treatment as compared to control cotton treatment (Figure **9**).

In the present study, application of green manure (dhancha) exhibited substantial and significant effects on various growth parameters (plant height, number of bolls, maturity %, boll weight and yield) of cotton. The difference in plant height at 60 days after sowing was not significant but as the nutrients from amendment of

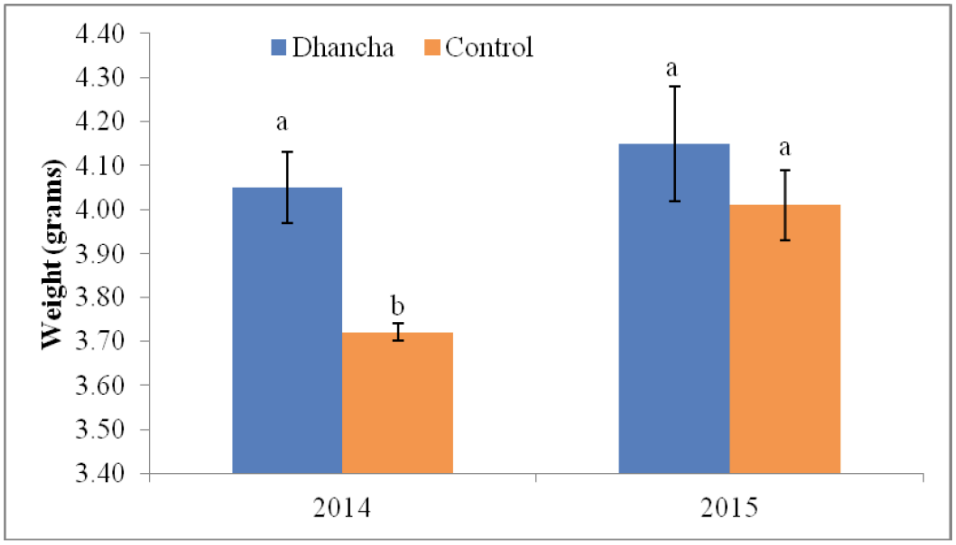

Figure 8: Effect of green manure (dhancha) on boll weight (g) (Mean±SE) of cotton during cropping seasons 2014 and 2015.

Means followed by the same letters against same year are not significantly different (P < 0.05).

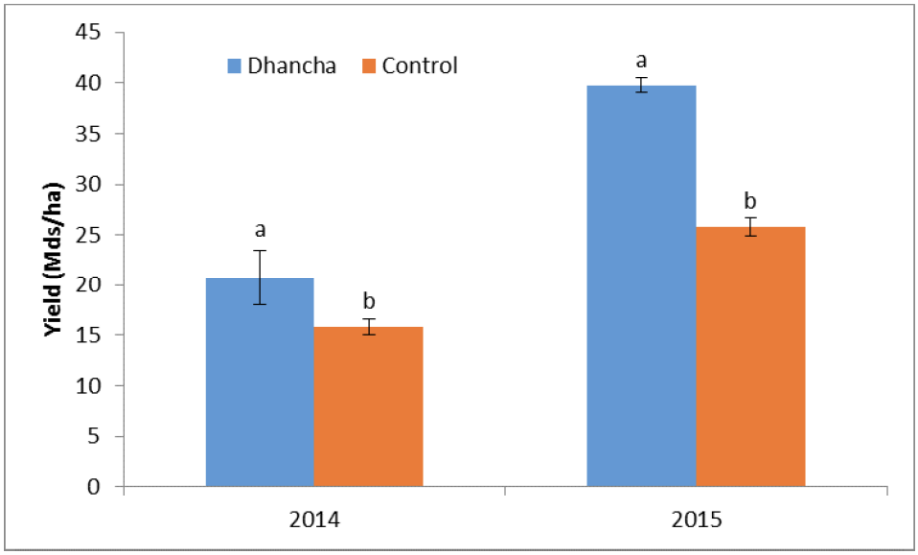

Figure 9: Effect of green manure (dhancha) on yield (Mean±SE) of cotton during cropping seasons 2014 and 2015. Means followed by the same letters against same year are not significantly different ($P < 0.05$).

green manure were made available, plant growth accelerated and became significantly higher than control. Similarly, other important yield parameters such as number of bolls and boll weight were also significantly higher and heavier than control. It shows the positive effect of green manure on yield of cotton. [24, 40] have also reported the significant effect of the of green manure on growth and yield traits of organically grown cotton as compared to traditionally cultivated cotton because of low pest incidence and more number of bolls per plan. Similar results have also been reported by [51-53], where comparatively higher yields were recorded in organic cotton treatments.

Bauer *et al.* [30] Observed significant impact of the application different green manures on yield and lint quality parameters of cotton as green manures provided readily available Nitrogen to cotton as compared to Urea. Eyhorn *et al.* [54] reported 30-40% higher gross margins from organic than conventional cotton production system However, [55] recorded similar pattern of yield and lint quality parameters of cotton with the application of organic and traditional methods. Accordingly, all above mentioned results supported the findings our study as comparatively higher yield was recorded in green manure applied treatment as compared to control.

CONCLUSION

In the present study of two years, in comparison to control plots, comparatively minimum population of sucking pests was recorded in treatment plots applied with green manure (Dhancha). Moreover, application of green manure also attract more population of predators as comparatively higher populations of *C. carnea, Orius* spp., *G. punctatis* and coccinellid predators were recorded in green manure treatment. Significant effect of application of neem oil during 2014 and fixing of *C. carnea* during 2015 was observed in the reduction of sucking pest population. Application of dhancha also showed improvement in the growth, yield quality parameters of cotton.

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