Effect of Different Sowing Dates on Insect Pest Population of Chillies (Capsicum annuam *L*)

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Abstract
Different strategies have to be involved for keeping the pest in check and stabilizing the productivity of the cropping system. Date of planting is one of the crop habitat diversifications that are to be looked into, to minimize the incidence of insect pests on chilli crop so that its yield can be enhanced. The present study was conducted to observe the activity of insect pests of chilli crop using variety P-777 at Kunri, Mirpur Khas Sindh during 2014 which was based on a randomized complete block design (RCBD) with four sowing dates, i.e. January 15th (SD1), January 30th (SD2), February 15th (SD3) and February 28th (SD4) and replicated thrice. The observation of insect pests was recorded at weekly intervals from first week of transplanting up to maturity. The results showed that the maximum mean aphids, thrips, jassids whitefly and fruit borer population of 0.527, 3.68, 0.46, 5.49 and 0.427 leaf-1 were found in SD4 and minimum of 0.36, 1.83, 0.01, 3.41 and 0.27 leaf-1 were present in SD1. However, the maximum bud mites population (0.381 leaf-1) was observed in SD1 followed by 0.26 mites leaf-1 in SD2 and minimum was found in SD3 and SD4 respectively. As regards to green pod yield, the finding of this study showed that maximum pod yield of 2.71 t ha-1 was produced in SD1 followed by 2.50 t ha-1 in SD2 and minimum yield of 1.72 leaf-1 was achieved in SD4. It is inferred that early sowing (January 15th or January 30th) resulted in lower incidence of aphids, thrips, whitefly and fruit borer except mites. Such low level of insect pest caused less crop injury which resulted in enhancing the green pod yield of chilli. So, it is suggested that for early sowing at Kunri region of Mirpur Khas the appropriate planting time can be January 15th and January 30th.
Keywords: Chillies, Insect Pest Population, and Different Sowing Dates

1. Introduction

Chilli (Capsicum annum L.) is an important commercial vegetable cum spice crop grown in Pakistan. The crop is known to harbour more than 50 insect and 2 mite pests of which, thrips, Scirtothrips dorsalis Hood and the mites, Polyphagotarsonemus latus Banks are the major constraints for higher yields (Reddy and Puttaswamy, 2000). These sucking pests attack the crop at seedling stage itself and continue until 1st harvest, causing severe crop losses up to 34 per cent (Ahmed et al., 2004). In addition recently, the pod borer, Helicoverpa armigera Hubner has also taken an upper hand and known to cause considerable damage to the crop by boring into the fruit leading to fruit whitening and fruit drop (Anonymous.,1999).

Aphids (Myzus persicae), thrip (Scirtothrips dorsalis), mites (Polyphagotarsonemus latus) and fruit borer (Helicoverpa armigera) are the major insect pests of chilli in Karnataka and elsewhere in the country, often resulting in significant crop losses (Ahmed et al., 2004 and Kandasamy et al., 1990). In order to save the crop from the pest ravages, farmers resort to six to as many as 20 rounds of chemical sprays (Lingappa et al., 2002) leading to pest resurgence, destruction of natural enemies and pesticide residues in fruits (David, 1991 and Smitha and Giraddi, 2006). As pesticide residues in chilli are of great concern from the point of exports and domestic consumption as well, nonchemical pest management strategies such as growing border crop of maize for the management of chilli pests is better approach. Capsicum species are not only cultivated as vegetable and condiment crop but are also incorporated into a number of medicinal preparations in the ancient literature around the world. 'Naga chilli' or 'Bhoot Jolokia' (Capsicum chinense Jacq.)

Thrips produces a silver white discolorations with tiny black dots (this is the insect's excrement) on the upper leaf surface. The leaves become distorted and flower and fruit production is affected. It likes hot, dry conditions so water temperature with shading and ventilation.

Whitefly produce lush new growth they become vulnerable to these aphids that spread viruses quickly and lead to the determent & health of the plant. The organic method is best to just hand pick them off, introduce ladybirds or a parasitic wasp (Encarsia Formosa) that can be purchased by specialists over the internet. The latter methods of biological control are only successful in greenhouses /polytunnels that can be sealed. Can be treated with Savona or insecticidal soap.

Under different sowing time and spacing was done. In the Scoville Organoleptic test, the highest Scoville Heat Unit (SHU) value was found in September 15 sowing fruits and the lowest in the February 15 sowing fruits. Fruit produced from spacing 105 cm × 105 cm showed highest Scoville Heat Unit. In High Performance Liquid Chromatography analysis, highest amount of capsaicinoid was also found in September 15 sowing while fruits produced from spacing 105 cm × 105 cm showed highest amount of capsaicinoid. Identification of Nordihydrocapsaicin, Capsaicin and Dihydrocapsaicin was done by comparing the retention time of sample with those of standard (Capsicum chinense Jacq.)

Chilies, red pepper or hot pepper, Capsicum annum L. belongs to the family Solanaceae, which is cultivated in Pakistan as a cash crop. Plant parts used for human consumption are its fruit and seeds. Chilies are rich in vitamins, especially vitamins A and C, and also contain appreciable amount of calcium, phosphorus and iron. The hot type chilies are a source of digestive stimulant (Baloch, 1996). It is grown on an area of 74784 hectares with 188859 tones production. Under field conditions, insects and mites in immense magnitude cause the losses to this crop.

Sow Chili seeds in a greenhouse from early February to April. They need warmth and a long period of time to fruit. They can be sown outside from early April in warmer southern parts of the country but they will need lots of sustained heat to produce a good crop, so it is better to sow indoors.

Sowing time is a major factor to influence the crop yields, earlier sowing times usually result in greater crop biomass, higher risk of lodging at the end of the season and increased risk of frost damage during flowering and pod setting. However, these risks can be outweighed by a longer growing season and subsequently higher yield potential. The optimum sowing time for maximizing yield varies with location (Brinsmead, 1992; Regan and Siddique, 2006). The early sown crops can suffer from lodging due to excessive vegetative growth. This was particularly evident in the early May sown crops; and the taller cultivars Howzat and Jimbour were more susceptible to lodging; this would be of concern on better soil types such as the grey clay in seasons of higher yield potential (Haigh and McMullen, 2012).

The optimum sowing date results in flowering occurring when the risk of cold temperatures is low, and it is especially important to avoid frost during flowering, which can kill chickpea plants (Whish et al., 2007). Earlier sowing can expose the crop to more rain events which can increase the disease risk (Matthews and McCaffery, 2011). Sandhu et al. (2007) reported that early flowering and podding cultivars had significantly higher green yields. Fresh yield measured at 75 days after sowing was far below those expected for late maturing chickpea crops. Singh et al. (2011) recommended 15 November to 15 December at a proper sowing time for chickpea. The chickpea sown on 30th November may yield 10-20 percent higher than the crop sown on 15th November or 15th December. Haigh and McMullen (2012) reported significant effects on crop biomass and grain yield due sowing on different dates. Bashir et al. (2008) also reported varied performance of chickpea varieties under similar input and management conditions.

1.1 Material and Methods

A field study was conducted at kunari, District Mirpur Khas Sindh during 2014 to investigate the effect of sowing dates on the insect pest population of chilies. Four sowing dates at 15 days intervals starting from January 15 to February 30 were considered as different treatments to find out the pest incidence, their damage severity and its effect on grain yield. There were four different sowing dates viz: SD 1 = 15th January; SD2 = 30th January; SD 3 = 15th February and SD4 =30th February. The experiment was laid out in Randomized Complete Block Design with three replications.The incidence of insect pests as a function of sowing times were studied in the form of population dynamics of aphids (Aphis gossypii Glover), thrips (Scirthothrips dorsalis Hood), Jassids ((Amrasca devastans Dist.), whiteflies (Bemisia tabaci Genn), and Bud mites (Eriophyes sheldoni) in field experiment by counting the population of insect pests on five randomly selected plants in each plot of 10.0 m x 8.0 m.

Nursery rising

Nursery of P-777 chilli variety was raised on well prepared one metre wide and three meters long strip in January and February during 2014 according to the sowing dates as per treatment. Before broadcasting the seeds, straws or farm yard manure were burned on the strips after which seeds were broadcast and pressed in the soil and covered with a thin layer of soil. These were then covered with layers of straws supported by wooden sticks with water application in the morning and evening till the seeds germinate. After germination straw was removed and water was applied after every 4-5 days. Within six weeks seedlings were ready for transplanting.

Land preparation and Transplanting

After land preparation, ridges of one and half foot high and wide were prepared. Transplanting was carried out on both sides of the ridges and distance between each plant was maintained at one and a half foot. Care was taken to avoid plants on both sides of ridges to face each other as this leads to dense plant population causing hindrances in weeding, harvesting, spraying etc. Transplanting was conducting in the evening, because in morning seedlings cannot withstand noon temperatures. After transplantation two watering were applied so that plants develop roots. Subsequent irrigation was applied as per climatic conditions. Transplanting was done in March and April.

Occurrence of Insect pests fauna in Chilies Capsicum annum L. Cultivation

Investigations on insect and mite pests were carried out from the beginning of chili growth period till the crop maturity, at kunari, District Mirpur Khas. Experimental site contained three replications in randomized complete block design. To study seasonal incidence of sucking pests of chilli were carried out and maintained without employing any plant protection measures. The observation of sucking pests was recorded at weekly intervals during morning hours between 6:30 AM to 8:30 AM. The population of thrips and whiteflies (nymphs and adults) were recorded from three leaves one each from the upper, middle and lower position on five randomly selected plants. For counting sucking pest populations, 3 leaves from top, middle and bottom portion of a plant were observed. Fruit borer's infestation was determined from 3 pods each from top, middle and bottom levels of selected plant.

Statistical analysis and interpretation of the data

The data for insect pests population dynamics of chilli were subjected to analysis of variance as described by Gomez and Gomez (1984) using software program Statistix 8.1. The related comparison of mean values was calculated using least significant difference (LSD) test at 0.05% significance level. The correlations were worked out between insect pests with climate factors where possible.

1.1.1 Results

Aphid population T The aphid population on chili after transplantation was monitored on weekly basis from 1st week of March to 4th week of August according to different sowing dates and the data as given in Appendix-I showed that weekly mean aphid population in SD1 was in the range of 0.0 to 0.82 leaf-1 with mean value of 0.377 leaf-1, in SD2 was from 0.011 to 1.10 leaf-1 with mean value of 0.46 leaf-1, in SD3 was from 0.021 to 1.16 leaf-1 with mean value of 0.49 leaf-1 and in SD4 was from 0.023 to 1.20 leaf-1 with mean value of 0.510 leaf-1.The Analysis of variance pertaining to population of Aphids under the influence of different sowing dates of chilli crop is shown in Appendix-II that revealed highly significant ($P<0.01$) mean aphids population leaf-1 in various sowing dates with F value of 29.59**. The LSD test (Fig.1) for comparison of treatment means ($P<0.05$) illustrated a maximum mean aphids population of 0.527 leaf-1 in SD4 followed by 0.48 leaf-1 in SD3 and minimum mean aphids population was 0.36 leaf-1 in SD1. Statically, all the four sowing dates (i.e. SD1 = January 15th, SD2 = January 30th, SD3 = February 15th and SD4 = February 28th) showed significant difference in mean aphid population leaf-1. The data regarding the weekly incidence of mean aphids leaf-1 under different sowing dates of chilli is given in Table 1. The peak mean aphid population leaf-1 (1.07 leaf-1) was recorded in the 4th week of June and lower (0.014 aphids leaf-1). The insect showed a rising trend from 1st week of March to 4th week of June and then a declining upto last week of August. Among the sowing dates, the peak mean population of aphids was recorded in 4th week of June in SD4 while no aphids was observed in 1st and 2nd week of March in SD1. The higher four weekly mean population of aphid in four sowing dates i.e. SD1, SD2, SD3 and SD4 was recorded in the month of June (0.64, 0.86, 0.91 and 0.93 leaf-1) and lower (0.008, 0.017, 0.028 and 0.032 leaf-1) in March respectively. The overall mean population of aphids revealed that SD4 showed higher mean population of 0.51 thrips leaf-1 followed by 0.49 leaf-1 in SD3 but lower (0.37leaf-1) was noted in SD1 (Table 1).

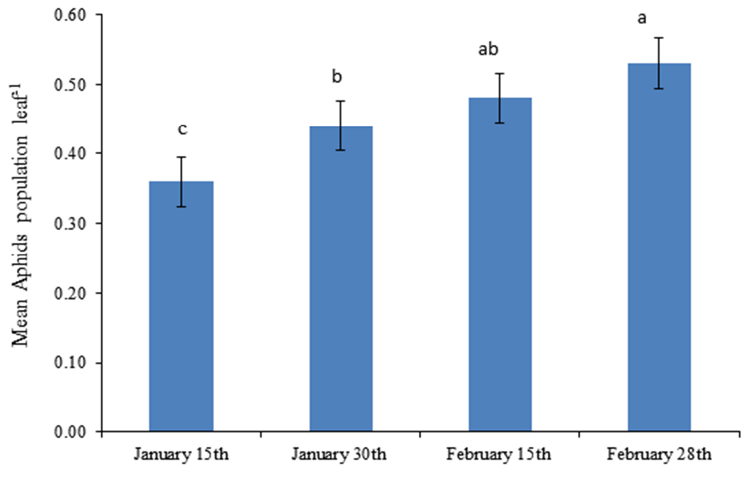

Fig. 1. Mean Aphids population per leaf of the chilli crop during entire growth period as affected by sowing date

Thrips population

The thrips population on chili after transplantation was monitored on weekly basis from 1st week of March to 4th week of August according to different sowing dates and the data as given in Appendix-I showed that weekly mean thrips population in SD1 was in the range of 0.0 to 4.75 leaf-1 with mean value of 1.90 leaf-1, in SD2 was from 0.0 to 7.87 leaf-1 with mean value of 3.25 leaf-1, in SD3 was from 0.01 to 8.08 leaf-1 with mean value of 1.20 leaf-1 and in SD4 was from 0.015 to 8.18 leaf-1 with mean value of 3.49 leaf-1.The Analysis of variance pertaining to population of thrips under the influence of different sowing dates of chilli crop is shown in Appendix-III that revealed significant ($P<0.01$) mean thrips population leaf-1 in various sowing dates with F value of 13.24*. The LSD test (Fig.2) for comparison of treatment means ($P<0.05$) depicted a maximum mean thrips population of 3.68 leaf-1 in SD4 followed by 3.33 leaf-1in SD3 and minimum mean thrips population of 1.83 leaf-1 was recorded in SD1. Statically, all the four sowing dates (i.e. SD1 = January 15th, SD2 = January 30th, SD3 = February 15th and SD4 = February 28th) showed non-significant difference in mean thrips population leaf-1 except in case SD1 which showed a significantly lower mean population of thrips leaf-1. The data regarding the weekly incidence of mean thrips leaf-1 under different sowing dates of chilli is given in Table 2. The peak mean thrips population was recorded in 4th week of August (6.69 thrips leaf-1) and June (6.24 leaf-1) while lower (0.01 thrips leaf-1) in 1st and 2nd weeks of March. The insect showed a rising trend from 1st week of March to 4th week of August except a little declining trend in July. Among the sowing dates, the peak mean population of thrips (6.69 leaf-1) was

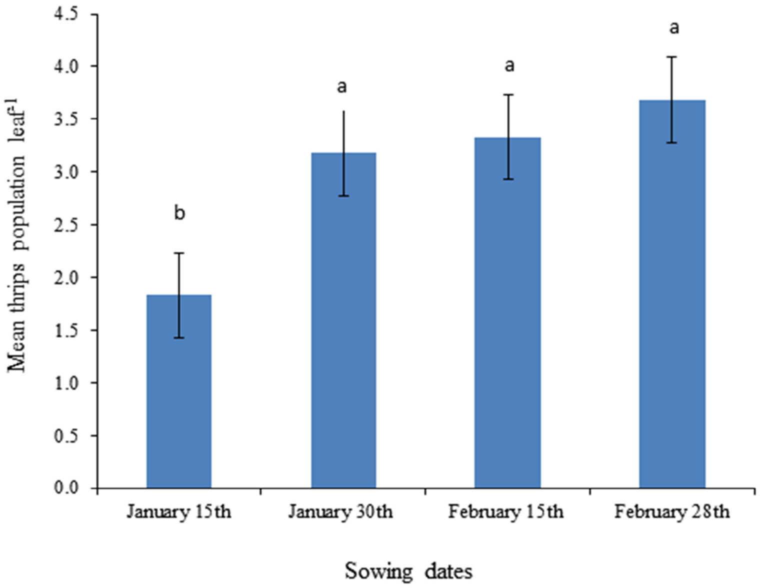

Fig. 2. Mean Thrips population per leaf of the chilli crop during entire growth period as affected by sowing dates

recorded in 4th week of August in SD4 while no thrips was observed in 1st and 2nd week of March in SD1 and SD2. The higher four weekly mean population of thrips in four sowing dates i.e. SD1, SD2, SD3 and SD4 was recorded in the month of Agust (2.45, 6.83, 7.02 and 7.12 leaf-1) and lower (0.0, 0.0, 0.015 and 0.068 leaf-1) in March respectively (Table 2). The overall mean population of thrips showed that SD4 showed higher mean population of 3.49 thrips leaf-1 followed by 3.41 leaf-1 in SD3 but lower (1.90 leaf-1) was noted in SD1 (Table 2).

Jassid population

The Jassids population on chili after transplantation was monitored on weekly basis from 1st week of March to 4th week of August according to different sowing dates and the data as given in Appendix-I showed that weekly mean Jassids population in SD1 was in the range of 0.0 to 0.40 leaf-1 with mean value of 0.244 leaf-1, in SD2 was from 0.0 to 0.54 leaf-1 with mean value of 0.291 leaf-1, in SD3 was from 0.02 to 0.253 leaf-1 with mean value of 0.283 leaf-1 and in SD4 was from 0.02 to 0.58 leaf-1 with mean value of 0.333 leaf-1.The Analysis of variance pertaining to population of Jassids under the influence of different sowing dates of chilli crop is shown in Appendix-IV that revealed significant ($P<0.01$) mean Jassids population leaf-1 in various sowing dates with F value of 30.48*. The LSD test (Fig.3) for comparison of treatment means ($P<0.05$) depicted a maximum mean Jassids population of 0.328 leaf-1 in SD4 followed by 0.294 leaf-1in SD3 and minimum mean Jassids population of 0.23 leaf-1 was recorded in SD1. Statically, all the four sowing dates (i.e. SD1 = January 15th, SD2 = January 30th, SD3 = February 15th and SD4 = February 28th) showed significant differences in mean Jassids population leaf-1 except in case SD2 and SD3 which showed statistically at par mean population of

Jassids leaf-1. The data regarding the weekly incidence of mean Jassids population leaf-1 under different sowing dates of chilli is given in Table 3. The peak mean Jassids population was recorded in 4th week of June (0.462 Jassids leaf-1) and July (0.483 Jassids leaf-1) while lower (0.01 Jassids leaf-1) in 1st week of March. The insect showed a rising trend from 1st week of March to 4th week of July. Among the sowing dates, the peak mean population of Jassids (0.584 leaf-1) was recorded in 2nd, 3rd and 4th week of June in SD4 followed by July. While no Jassid was observed in 1st and 2nd week of March in SD1 and SD2. The higher four weekly mean population of Jassids in four sowing dates i.e. SD1, SD2, SD3 and SD4 was recorded in the month of June (0.375, 0.503, 0.340 and 0.548 leaf-1) and lower (0.0, 0.0, 0.053 and 0.060 leaf-1) in March respectively (Table 3). The overall mean population of Jassids showed higher mean Jassids population of 0.333 leaf-1 in SD4 followed by 0.283 leaf-1 in SD3 but lower (0.244 leaf-1) was noted in SD1 (Table 3).

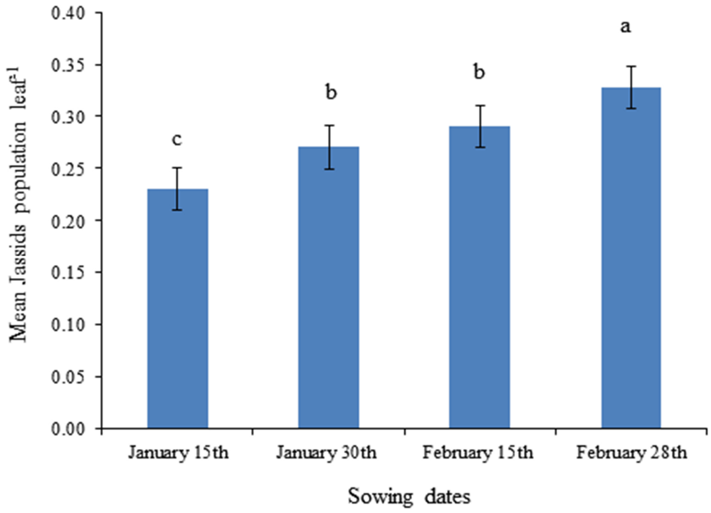

Fig. 3. Mean Jassids population per leaf of chilli crop during entire growth period as affected by sowing dates

Bud Mites population

The bud mites population on chili after transplantation was monitored on weekly basis from 1st week of March to 4th week of August according to different sowing dates and the data as given in Appendix-I showed that mean mites population in SD1 was in the range of 0.0 to 0.83 mites leaf-1 with mean value of 0.39 mites leaf-1, in SD2 was from 0.0 to 0.598 mites leaf-1 with mean value of 0.273 mites leaf-1, in SD3 was from 0.0 to 0.435 leaf-1 with mean value of 0.207 mites leaf-1 and in SD4 was from 0.0 to 0.405 mites leaf-1 with mean value of 0.180 mites leaf-1.The Analysis of variance about the population of mites under the influence of different sowing dates of chilli crop is shown in Appendix-V that revealed significant ($P<0.01$) mean mites population leaf-1 in various sowing dates with F value of 348.11**. The LSD test (Fig.4) for comparison of treatment means ($P<0.05$) revealed a maximum mean mites population of 0.381 leaf-1 in SD1 followed by 0.26 leaf-1in SD2 and minimum mean mites population of 0.17 leaf-1 was recorded in SD4. Statically, all the four sowing dates (i.e. SD1 = January 15th, SD2 = January 30th, SD3 = February 15th and SD4 = February 28th) showed significant difference in mean mites population leaf-1 as indicated by CV of 3.48% and LSD value of 0.0175 (Appendix-IX).The data regarding the weekly incidence of mean population of mites leaf-1 under different sowing dates of chilli is given in Table 3. The peak mean mites population was recorded in 4th week of March and April (0.536 leaf-1) followed by 0.396 mites leaf-1 in 1st week of May while lower (0.124 mites leaf-1) was recorded in the 4th week of August. However, in the month of June and July no mites population was observed. The insect showed an increasing trend from 1st week of March to 1st week of May and then no appearance during two months of June and July but reappeared in the month of August. Among the sowing dates, the weekly peak mean population of mites (0.83 leaf-1) was recorded in 4th week of March followed by 0.75 mites leaf-1 in 4th week of April in SD1 and minimum of 0.05 mites leaf-1 was noted in 4th week of August while no mites was observed in all four sowing dated during June and July. The higher four weekly mean population of mites in four sowing dates i.e. SD1, SD2, SD3 and SD4 was recorded in the month of March (0.678, 0.488, 0.312 and 0.271 mites leaf-1) and lower (0.195, 0.109, 0.09 and 0.043 leaf-1) in August respectively (Table 3). The overall mean population of mites showed that SD1 showed higher mean population of 0.392 mites leaf-1 followed by 0.273 mites leaf-1 in SD2 but lower (0.180 mites leaf-1) was noted in SD4 (Table 3).

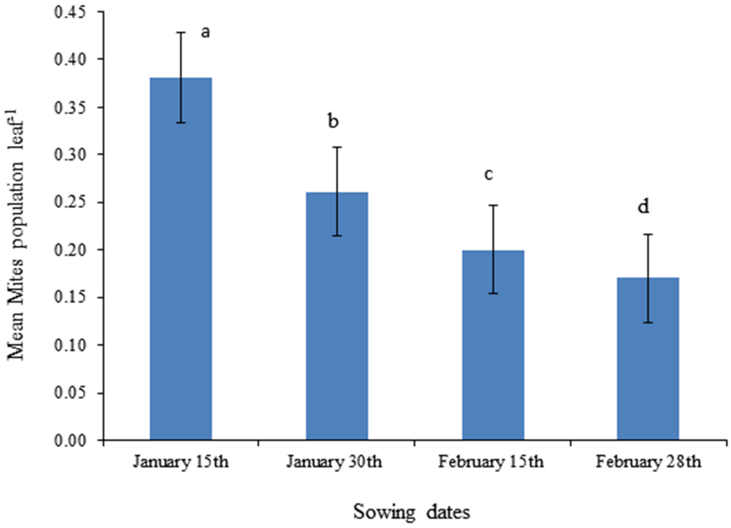

Fig. 4. Mean bud mites population per leaf of chilli crop entire growth period as affected by sowing dates

Whitefly population

The whitefly population on chili crop after transplantation was monitored on weekly basis from 1st week of March to 4th week of August according to different sowing dates and the data as given in Appendix-I showed that mean whitefly population in SD1 was in the range of 0.18 to 6.60 leaf-1 with mean value of 3.70 leaf-1, in SD2 was from 0.24 to 8.84 whitefly leaf-1 with mean value of 5.33 whitefly leaf-1, in SD3 was from 0.30 to 9.37 leaf-1 with mean value of 5.64 leaf-1 and in SD4 was from 0.35 to 9.64 leaf-1 with mean value of 5.79 whitefly leaf-1.The Analysis of variance about the population of whitefly under the influence of different sowing dates of chilli crop is shown in Appendix-VI that revealed significant ($P<0.01$) mean whitefly population leaf-1 in various sowing dates with F value of 93.04**. The LSD test (Fig.5) for comparison of treatment means ($P<0.05$) revealed a maximum mean whitefly population of 5.49 leaf-1 in SD4 followed by 5.37 whitefly leaf-1 in SD3 and minimum mean whitefly population of 3.41 leaf-1 was recorded in SD1. Statically, all the four sowing dates (i.e. SD1 = January 15th, SD2 = January 30th, SD3 = February 15th and SD4 = February 28th) showed significant difference in mean whitefly population leaf-1 as indicated by CV of 3.58% and LSD value of 0.344 but SD4 and SD3 were statistically non-significant (Appendix-IX).The data regarding the weekly incidence of mean population of whitefly leaf-1 under different sowing dates of chilli is given in Table 4. The peak mean whitefly population was recorded in April, May and June in all four weeks while lower was recorded in the 4th week of August. The whitefly population remain higher with sustainably in three months i.e April, May and June and then started to decline in

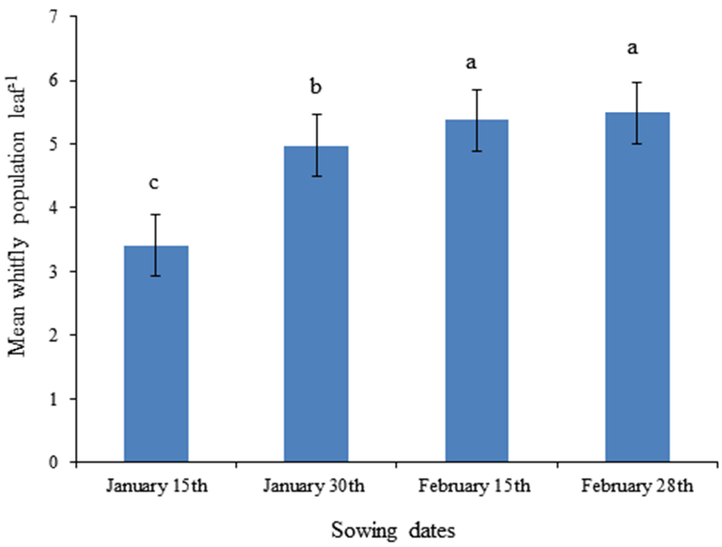

Fig. 5. Mean whitefly population per leaf of chilli crop entire growth period as affected by sowing dates

the other two last months i.e .July and August. Among the sowing dates, the weekly peak mean population of whitefly remain in a proximity level in all four weeks during April, May, June and July but was lower in March. However, in the month of August the whitefly population started to decline abruptly (Table 4). The overall mean population of whitefly showed that SD4 indicated higher mean population of 5.79 whitefly leaf-1 followed by 5.64 whitefly leaf-1 in SD3 but lower (3.70 whitefly leaf-1) was noted in SD1 (Table 4).

Fruit borer population

The fruit borer population plant-1 on chili crop after transplantation was monitored on weekly basis from 1st week of March to 4th week of August according to different sowing dates and the data as given in Appendix-I showed that mean fruit borer plant-1 population in SD1 was in the range of 0.0 to 1.12 plant-1with mean value of 0.27 plant-1, in SD2 was from 0.0 to 1.50 fruit borer plant-1 with mean value of 0.35 fruit borer plant-1, in SD3 was from 0.0 to 1.59 plant-1with mean value of 0.37 plant-1and in SD4 was from 0.0 to 1.64 plant-1with mean value of 0.38 fruit borer plant-1.The Analysis of variance about the population of fruit borer plant-1under the influence of different sowing dates of chilli crop is shown in Appendix-VII that revealed significant (P<0.01) mean whitefly population leaf-1 in various sowing dates with F value of 17.15**. The LSD test (Fig.6) for comparison of treatment means (P<0.05) revealed a maximum mean fruit borer population of 0.427 plant-1 in SD4 followed by 0.400 fruit borer plant-1 in SD3 and minimum mean fruit borer plant-1 population of 0.27 leaf-1 was recorded in SD1. Statically, all the four sowing dates (i.e. SD1 = January 15th, SD2

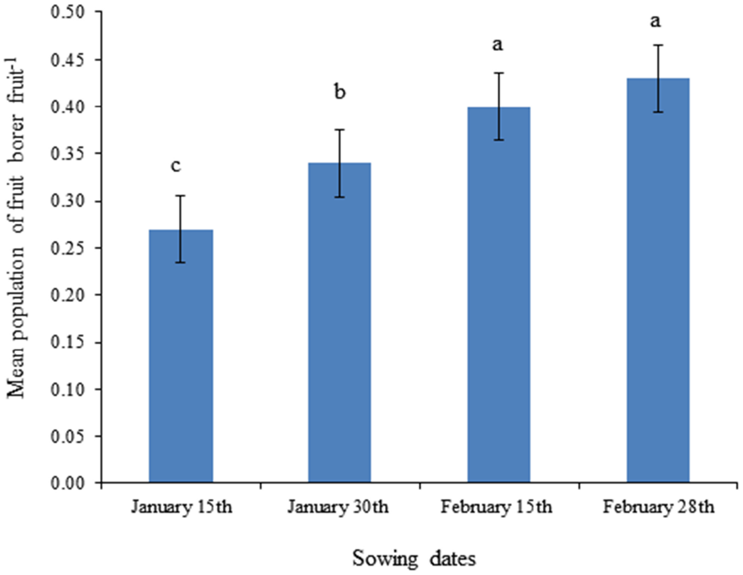

Fig. 6. Mean fruit borer population per fruit of chilli crop entire growth period as affected by sowing dates

February 28th) showed significant difference in mean fruit borer plant-1 population leaf-1 as indicated by CV of 7.98% and LSD value of 0.057 but SD4 and SD3 were statistically non-significant from each other (Appendix-IX).

The data regarding the weekly incidence of mean population of fruit borer plant-1 under different sowing dates of chilli is given in Table 5. The peak mean fruit borer plant-1 population was recorded in 3rd and 4th week of June and 1st and 2nd week of July while lower (0.03 fruit borer plant-1) was recorded in the 4th week of August. No fruit borer incidence was recorded in the month of March, April and May. Among the sowing dates, the weekly peak mean population of fruit borer plant-1 was noted in June but was lower in August. The overall mean population of fruit borer showed that SD4 indicated higher mean population of 0.38 fruit borer plant-1followed by 0.37 fruit borer plant-1in SD3 but lower (0.27 fruit borer plant-1) was noted in SD1 (Table 5).

Yield

The green pod yield of chili crop was affected by the incidence of insect pests and the data showed that the overall chilli green pod yield was in the range of 1.22 to 3.51 t ha-1 with mean yield of 2.21 t ha-1 (Fig. 7).

The Analysis of variance about the yield of chilli under the influence of different sowing dates of chilli crop is shown in Appendix-VII that revealed significant (P<0.01) mean yield in various sowing dates with F value of 34.81**. The LSD test (Fig.6) for comparison of treatment means (P<0.05) revealed a maximum pod yield of 2.71 t ha-1 was produced in SD1 followed by 2.50 t ha-1 in SD2 and minimum yield of 1.72 leaf-1 was achieved in SD4. Statically, all the four sowing dates (i.e. SD1 = January 15th, SD2 = January 30th, SD3 = February 15th and

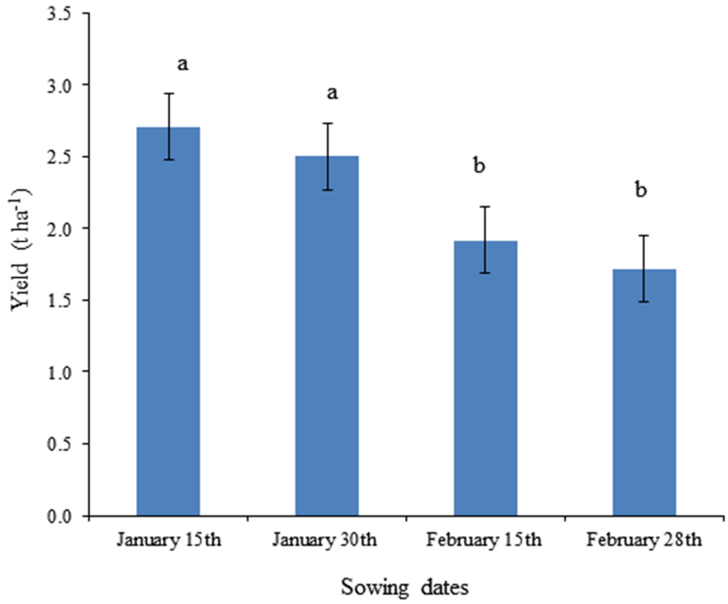

Fig. 7. Yield (t ha-1) of chilli crop as affected by sowing dates

SD4 = February 28th) showed significant difference in yield as indicated by CV of 6.20% and LSD value of 0.274. Statistically, both SD1 and SD2 were non-significantly over SD4 and SD3 (Appendix-VIII).

Correlation

The correlation was worked out to observe any relationship between insect pest of chilli and temperature under the influence of different sowing dates (Fig. 7-9) which revealed that the mean population of aphids leaf-1 of chilli was positively, but non-significantly correlated with maximum weekly temperature and its coefficient of determination (R2) was 38% (Fig 8). In case of whitefly, there was also positive and non-significant correlation existed between mean whitefly population leaf-1 and weekly maximum temperature with an R2 value of 39% (Fig. 9). However, the mean population of mites leaf-1 was negatively and non-significantly correlated with weekly maximum temperature with a 16% coefficient of determination (R2) (Fig.10).

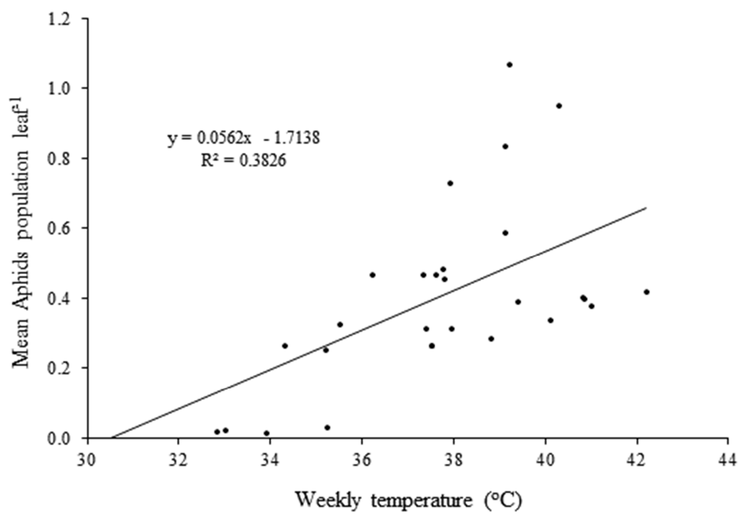

Fig. 8. Correlation between weekly temperature and mean population of Aphids per leaf of chilli crop as affected by sowing dates

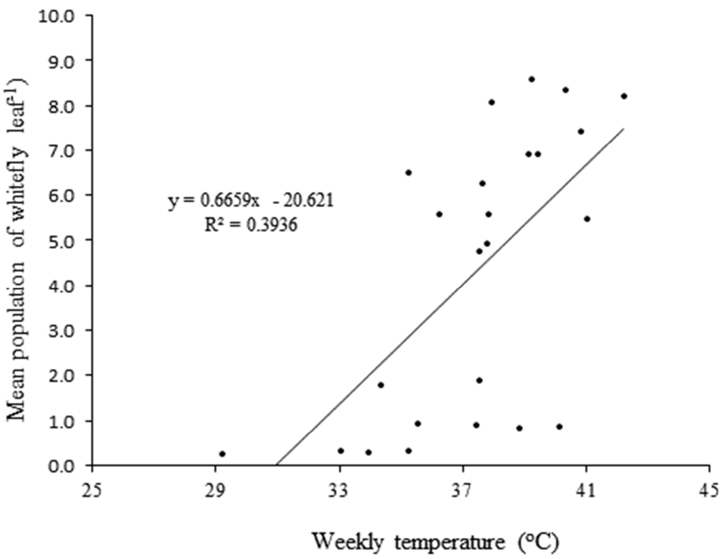

Fig. 9. Correlation between weekly temperature and mean population of whitefly per leaf of chilli crop as affected by sowing dates

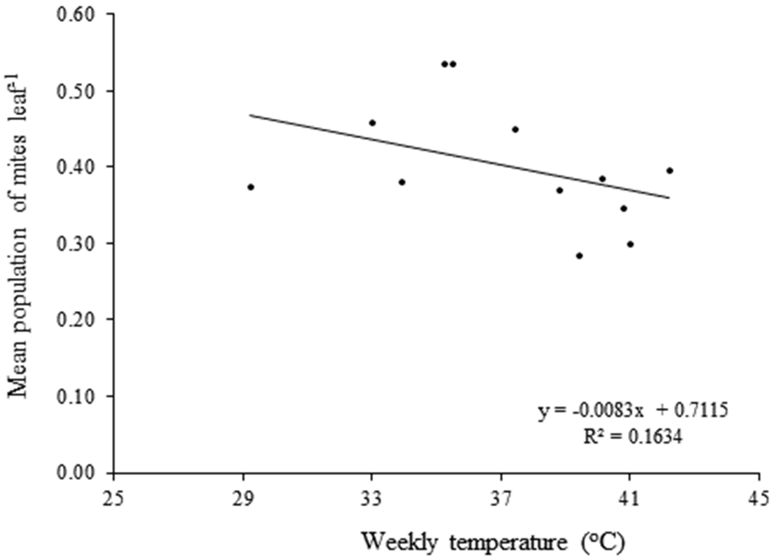

Fig. 10. Correlation between weekly temperature and mean population of mites per leaf of chilli crop as affected by sowing dates

Discussion

Different strategies have to be involved for keeping the pest in check and stabilizing the productivity of cropping system. Date of planting is one of the crop habitat diversifications that are to be looked into, to minimize the incidence of insect pests on chilli crop so that its yield can be enhanced. However, there is no much information in literature to suggest the effect of date of planting on the activity of sucking pests except very few reports. The present study was conducted to observe the activity of insect pests of chilli crop at Kunri, Mirpur Khas Sindh during 2014 aimed to enhance its yield with minimum insect pests injury. In this study five insect pests including aphids (Aphis gossypii Glover), thrips (Scirthothrips dorsalis Hood), mites (Polypha gotarsonemus latus Banks) whiteflies (Bemisia tabaci Genn) and fruit borer (Helicoverpa armigera (Hubner) were monitored and the effect of plant dating was investigated on chilli green pod production.

The results regarding mean aphids population leaf-1 showed that maximum mean aphids population of 0.527 leaf-1 was recorded in SD4 followed by 0.48 leaf-1 in SD3 and minimum mean aphids population was 0.36 leaf-1 in SD1. The peak mean aphid population (1.07 leaf-1) was recorded in the 4th week of June and lower (0.014 aphids leaf-1) in 1st week of March. The aphids population showed a rising trend from 1st week of March to 4th week of June and then a declining upto last week of August. The overall mean population of aphids revealed that SD4 showed higher mean population of 0.51 thrips leaf-1 followed by 0.49 leaf-1 in SD3 but lower

(0.37leaf-1) was noted in SD1. The high aphids population in the month of June is might be due to high temperature in this growth period which is indicated by the positive correlation between mean aphids population leaf-1 and weekly maximum temperature. The chilli crop sown in the month of January suggested less level aphids population. The present investigations are in close agreement with Anon (2004) who reported that the weather parameters like precipitation, sunlight and relative humidity have been reported to be optimum for transplanting of Byadagi chilli during July in the region, leading to better rooting and establishment. He further showed that late planting, as it is known in many crops, attracts greater intensity of pests and subsequent plant damage.

As regard to mean thrips population leaf-1 the present investigation revealed that maximum mean thrips population of 3.68 leaf-1 in SD4 followed by 3.33 leaf-1in SD3 and minimum mean thrips population of 1.83 leaf-1 was recorded in SD1. The peak mean thrips population was recorded in 4th week of August (6.69 thrips leaf-1) and June (6.24 leaf-1) while lower (0.01 thrips leaf-1) in 1st and 2nd weeks of March. The insect showed a rising trend from 1st week of March to 4th week of August except a little declining trend in July. The overall mean population of thrips showed that SD4 showed higher mean population of 3.49 thrips leaf-1 followed by 3.41 leaf-1 in SD3 but lower (1.90 leaf-1) was noted in SD1. This high thrips population in the months of June and August is also due high weekly temperature. Because late planting i.e. SD4 reach to maturity later and become more liable to insect pest attacks. It can be seen from the early sowing i.e. January 15th that revealed the overall low population of thrips per leaf. Similar results were also found by Sujay and Giraddi (2014) that late planted crop was liable for heavy infestation by insect pests and mites. Time of transplanting of chilli influences the incidence of pests and diseases.

maximum mean Jassids population of 0.328 leaf-1 in SD4 followed by 0.294 leaf-1in SD3 and minimum mean Jassids population of 0.23 leaf-1 was recorded in SD1. The peak mean Jassids population was recorded in 4th week of June (0.462 Jassids leaf-1) and July (0.483 Jassids leaf-1) while lower (0.01 Jassids leaf-1) in 1st week of March. The insect showed a rising trend from 1st week of March to 4th week of July. Among the sowing dates, the peak mean population of Jassids (0.584 leaf-1) was recorded in 2nd, 3rd and 4th week of June in SD4 followed by July. While no Jassid was observed in 1st and 2nd week of March in SD1 and SD2. The overall mean population of Jassids showed higher mean Jassids population of 0.333 leaf-1 in SD4 followed by 0.283 leaf-1 in SD3 but lower (0.244 leaf-1) was noted in SD1. This high population of Jassids in the months of June and July is might be due to high temperature. Similar results were reported by Aheer et al. (1994) that the incidence and development of these insect pests is very much dependent upon the prevailing physical environmental factors and crop stand. These insets multiply tremendously during the favourable weather conditions and take huge toll. The role of temperature and relative humidity is likely to affect the occurrence.

The results about mean mites population leaf-1 showed that the maximum mean mites population of 0.381 leaf-1 was noted in SD1 followed by 0.26 leaf-1 in SD2 and minimum mean mites population of 0.17 leaf-1 was recorded in SD4. The peak mean mites population was recorded in 4th week of March and April (0.536 leaf-1) followed by 0.396 mites leaf-1 in 1st week of May while lower (0.124 mites leaf-1) was recorded in the 4th week of August. However, in the month of June and July no mites population was observed. The insect showed an increasing trend from 1st week of March to 1st week of May and then no appearance during two months of June and July but reappeared in the month of August. The overall mean population of mites showed that SD1 showed higher mean population of 0.392 mites leaf-1 followed by 0.273 mites leaf-1 in SD2 but lower (0.180 mites leaf-1) was noted in SD4. This high mites population in SD1 and SD2 is might be due optimum temperature because the increasing temperature affects its population which is indicated by the negative relationship between number of mean mites population leaf-1 and weekly maximum temperature as shown in Fig-9.

As regard to the pooled data pertaining to mean population of whitefly leaf-1 revealed that maximum mean whitefly population of 5.49 leaf-1 was present in SD4 followed by 5.37 whitefly leaf-1 in SD3 and minimum mean whitefly population of 3.41 leaf-1 was recorded in SD1. The peak mean whitefly population was recorded in April, May and June in all four weeks while lower was recorded in the 4th week of August. The whitefly population remain higher with sustainably in three months i.e April, May and June and then started to decline in the other two last months i.e .July and August. The overall mean population of whitefly showed that SD4 indicated higher mean population of 5.79 whitefly leaf-1 followed by 5.64 whitefly leaf-1 in SD3 but lower (3.70 whitefly leaf-1) was noted in SD1. Similar findings were shown by Khalid et al. (2009) that the number of whitefly increased to a peak at the earlier cropping period but declined towards the end of the cropping period. They further indicated that the number of whitefly was significantly higher ($p < 0.05$) in the middle than in the early and late of planting seasons. This study is also in agreement with the findings of Gerling et al. (1980) who suggested such population trend might be related with the physiological conditions of the plant. Among the sowing dates, January 15th (SD1) and January 30th (SD2) indicated less number of whitefly which suggests that in low temperature its population remain low.

The results regarding to the population of fruit borers plant-1 showed that maximum mean fruit borer population

(0.427 plant-1) was registered in SD4 followed by 0.400 fruit borer plant-1 in SD3 and minimum mean fruit borer plant-1 population of 0.27 leaf-1 was recorded in SD1. The peak mean fruit borer plant-1 population was recorded in 3rd and 4th week of June and 1st and 2nd week of July while lower (0.03 fruit borer plant-1) was recorded in the 4th week of August. No fruit borer incidence was recorded in the month of March, April and May. The overall mean population of fruit borer showed that SD4 indicated higher mean population of 0.38 fruit borer plant-1followed by 0.37 fruit borer plant-1in SD3 but lower (0.27 fruit borer plant-1) was noted in SD1. The severe fruit borer attack in the month of June and July suggesting that their population was due to high temperature during this period of growth as given the Appendix-IX but at the time maturity i.e. in the month of August when the temperature become comparatively low helps in declining its population.
As regard to green pod yield the finding of this study showed that maximum pod yield of 2.71 t ha-1 was produced in SD1 followed by 2.50 t ha-1 in SD2 and minimum yield of 1.72 leaf-1 was achieved in SD4. As reported by Berke and Sheih (2000) that one of the practical means of increasing chilli production is to minimize losses caused by major sucking pests, the most important among them are green peach aphid (Myzys persicae Sulzer, Aphis gossypi Glover), thrips (Scirtothrips dorsalis Hood) and yellow mite (Polyphagotarsonemus latus Banks). The yield losses due to these pests are estimated to be 50 per cent (Ahmed et al., 1987; Kandasamy et al., 1990 and Hosmani, 2007). The loss caused by the thrips is reported to range from 50 to 90 per cent (Borah, 1987) and fruit borers is to an extent of 90 per cent (Reddy and Reddy, 1999).

Conclusions

In the light of pooled data regarding insect pests of chilli as affected by sowing dates as a pest control measure, it is concluded that early sowing (January 15th or January 30th) resulted in low incidence of aphids, thrips, Jassids, whitefly and fruit borer except mites. Such low level of insect pest caused less crop injury which resulted in enhancing green pod yield of chilli. So, it is suggested that for early sowing at Kunri region of Mirpur Khas the appropriate planting time can be January 15th and/or January 30th.

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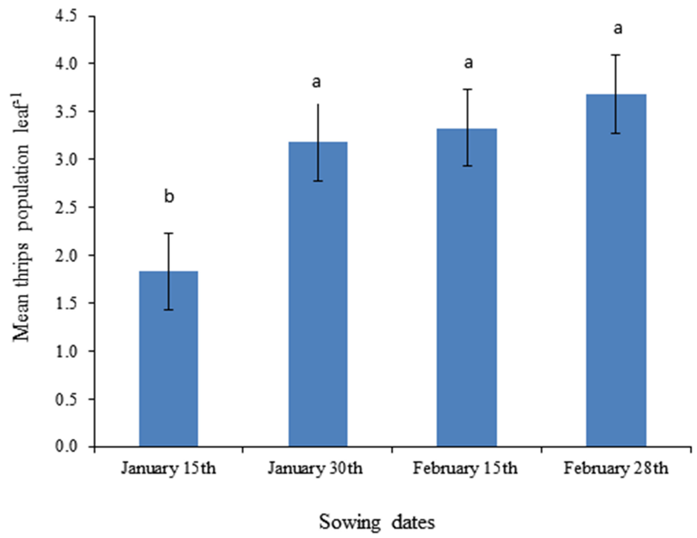

Nodes plant-1

The results pertaining to nodes plant-1 of maize as influenced by different integrated levels of potassium and zinc are presented in Table-3 and their analysis of variance as Appendix-III. The analysis of variance showed that various levels of potassium and zinc either sole or integrated affected positively and significantly ($P<0.05$) maize nodes plant-1 as compared to No Potassium + No Zinc (Control).The data indicated that integrated application of Potassium @ 60.0 kg ha-1 + Zinc @ 10.0 kg ha-1 resulted in maximum nodes plant-1 (5.91) of maize, closely followed by Potassium @ 60.0 kg ha-1 + Zinc @ 5.0 kg ha-1 and Potassium @ 40.0 kg ha-1 + Zinc @ 10.0 kg ha-1 with nodes plant-1 of 5.80 and 5.75, respectively showing the non-significant ($P>0.05$) differences of above treatments with each other. The maize nodes plant-1 reduced to 5.17, 3.61, 3.34, 3.01 and 2.74 in plots receiving Potassium @ 40.0 kg ha-1 + Zinc @ 5.0 kg ha-1, Potassium @ 60.0 kg ha-1, Potassium @ 40.0 kg ha-1, Zinc @ 10.0 kg ha-1 and Zinc @ 5.0 kg ha-1, respectively. However, minimum nodes plant-1 (2.34) of maize was recorded in plots receiving No Potassium + No Zinc (Control). The overall data suggested that sole application of potassium and zinc also demonstrated significant effects on nodes plant-1 of maize as compared to control plot, but the integrated application of potassium and zinc was more effective than their sole application.

Table 3. Nodes plant^{-1} of maize as influenced by integrated levels of potassium and zinc

Treatments	**R-I**	**R-II**	**R-III**	**Mean**
No Potassium + No Zinc (Control)	2.41	2.41	2.21	**2.34 g**
Potassium @ 40.0 kg ha^{-1}	3.41	3.21	3.41	**3.34 d**
Potassium @ 60.0 kg ha^{-1}	3.61	3.41	3.81	**3.61 c**
Zinc @ 5.0 kg ha^{-1}	2.61	2.81	2.81	**2.74 f**
Zinc @ 10.0 kg ha^{-1}	3.01	3.01	3.01	**3.01 e**
Potassium @ 40.0 kg ha^{-1} + Zinc @ 5.0 kg ha^{-1}	5.01	5.00	5.50	**5.17 b**
Potassium @ 40.0 kg ha^{-1} + Zinc @ 10.0 kg ha^{-1}	5.65	5.75	5.85	**5.75 a**
Potassium @ 60.0 kg ha^{-1} + Zinc @ 5.0 kg ha^{-1}	5.70	5.80	5.90	**5.80 a**
Potassium @ 60.0 kg ha^{-1} + Zinc @ 10.0 kg ha^{-1}	5.81	5.91	6.01	**5.91 a**

Means not sharing the same letter in a column differ significantly at 0.05 probability level.

SE±	0.1057
LSD $_{0.05}$	0.2241
LSD $_{0.01}$	0.3087
CV%	3.09

Number of green leaves per plant:

Number of green leaves in maize for fodder production is a quantity parameter; but this trait is generally influenced by level of input application. The results in regards to the number of green leave plant-1 of fodder maize as influenced by different irrigation intervals are shown in Fig.3. The analysis of variance Table 3 indicated significant ($P \leq 0.05$) impact of various irrigation intervals on the number of green leaves plant-1 of fodder maize. The results showed (Fig.3) that maximum number of green leaves plant-1 (13.42) on average was achieved in crop given 1st irrigation at 20 days after sowing, 2nd at 35 days and 3rd after 50 days of sowing (T1); by the delay in the first irrigation the number of green leaves plant-1 slightly decreased to (12.70) and (11.10) in T3 and T4 treatments, respectively.

Table 4. Green leaves plant^{-1} of maize as influenced by integrated levels of potassium and zinc

Treatments	R-I	R-II	R-III	Mean
No Potassium + No Zinc (Control)	7.29	7.09	6.89	**7.09 g**
Potassium @ 40.0 kg ha^{-1}	9.89	9.49	9.69	**9.69 d**
Potassium @ 60.0 kg ha^{-1}	11.09	10.69	10.89	**10.89 c**
Zinc @ 5.0 kg ha^{-1}	7.89	7.69	7.69	**7.76 f**
Zinc @ 10.0 kg ha^{-1}	8.89	8.69	8.49	**8.69 e**
Potassium @ 40.0 kg ha^{-1} + Zinc @ 5.0 kg ha^{-1}	15.49	15.00	14.89	**15.13 b**
Potassium @ 40.0 kg ha^{-1} + Zinc @ 10.0 kg ha^{-1}	15.85	15.45	15.65	**15.65 a**
Potassium @ 60.0 kg ha^{-1} + Zinc @ 5.0 kg ha^{-1}	15.88	15.48	15.68	**15.68 a**
Potassium @ 60.0 kg ha^{-1} + Zinc @ 10.0 kg ha^{-1}	16.09	15.69	15.89	**15.89 a**

Means not sharing the same letter in a column differ significantly at 0.05 probability level.

SE±	0.0861
$LSD_{0.05}$	0.1825
$LSD_{0.01}$	0.2514

Leaf length (cm)

The results regarding leaf length (cm) of maize as influenced by different integrated levels of potassium and zinc are presented in Table-5 and their analysis of variance as Appendix-V. The analysis of variance showed that various levels of potassium and zinc either sole or integrated affected positively and significantly ($P<0.05$) maize leaf length(cm) as compared to No Potassium + No Zinc (Control).The data indicated that integrated application of Potassium @ 60.0 kg ha-1 + Zinc @ 10.0 kg ha-1 resulted in maximum leaf length (48.55 cm) of maize, closely followed by Potassium @ 60.0 kg ha-1 + Zinc @ 5.0 kg ha-1 and Potassium @ 40.0 kg ha-1 + Zinc @ 10.0 kg ha-1 with leaf length of 47.96 and 47.48 cm, respectively showing the non-significant ($P>0.05$) differences of above treatments with each other. The maize leaf length reduced to 43.44, 41.66, 40.55, 29.00 and 27.55 cm in plots receiving Potassium @ 40.0 kg ha-1 + Zinc @ 5.0 kg ha-1, Potassium @ 60.0 kg ha-1, Potassium @ 40.0 kg ha-1, Zinc @ 10.0 kg ha-1 and Zinc @ 5.0 kg ha-1, respectively. However, the minimum leaf length (23.66 cm) of maize was recorded in plots receiving No Potassium + No Zinc (Control). The overall data suggested that sole application of potassium and zinc also demonstrated significant effects on leaf length of maize as compared to control plot but the integrated application of potassium and zinc was more effective than their sole application.

Table 5. Leaf length (cm) of maize as influenced by integrated levels of potassium and zinc

Treatments	R-I	R-II	R-III	Mean
No Potassium + No Zinc (Control)	24.00	23.33	23.66	**23.66 f**
Potassium @ 40.0 kg ha^{-1}	40.00	40.66	41.00	**40.55 c**
Potassium @ 60.0 kg ha^{-1}	41.66	42.00	41.33	**41.66 c**
Zinc @ 5.0 kg ha^{-1}	28.00	27.00	27.66	**27.55 e**
Zinc @ 10.0 kg ha^{-1}	30.00	29.00	28.00	**29.00 d**
Potassium @ 40.0 kg ha^{-1} + Zinc @ 5.0 kg ha^{-1}	44.00	43.00	43.33	**43.44 b**
Potassium @ 40.0 kg ha^{-1} + Zinc @ 10.0 kg ha^{-1}	47.26	46.59	48.59	**47.48 a**
Potassium @ 60.0 kg ha^{-1} + Zinc @ 5.0 kg ha^{-1}	47.74	47.07	49.07	**47.96 a**
Potassium @ 60.0 kg ha^{-1} + Zinc @ 10.0 kg ha^{-1}	48.33	47.66	49.66	**48.55 a**

Means not sharing the same letter in a column differ significantly at 0.05 probability level.

SE±	0.5779
LSD $_{0.05}$	1.2252
LSD $_{0.01}$	1.6881
CV%	1.82

Stem girth (cm)

The results regarding stem girth (cm) of maize as influenced by different integrated levels of potassium and zinc are presented in Table-6 and their analysis of variance as Appendix-VI. The analysis of variance showed that various levels of potassium and zinc either sole or integrated affected positively and significantly (P<0.05) maize stem girth(cm) as compared to No Potassium + No Zinc (Control).The data indicated that integrated application of Potassium @ 60.0 kg ha-1 + Zinc @ 10.0 kg ha-1 resulted in maximum stem girth (4.10 cm) of maize, closely followed by Potassium @ 60.0 kg ha-1 + Zinc @ 5.0 kg ha-1 and Potassium @ 40.0 kg ha-1 + Zinc @ 10.0 kg ha-1 with stem girth of 4.04 and 3.89 cm, respectively showing the non-significant (P>0.05) differences of above treatments with each other. The maize stem girth reduced to 3.45, 3.20, 3.05, 2.84 and 2.67 cm in plots receiving Potassium @ 40.0 kg ha-1 + Zinc @ 5.0 kg ha-1, Potassium @ 60.0 kg ha-1, Potassium @ 40.0 kg ha-1, Zinc @ 10.0 kg ha-1 and Zinc @ 5.0 kg ha-1, respectively. However, minimum stem girth (2.51 cm) of maize was recorded in plots receiving No Potassium + No Zinc (Control). The overall data suggested that sole application of potassium and zinc also demonstrated significant effects on stem girth of maize as compared to control plot, but the integrated application of potassium and zinc was more effective than their sole application.

Table 6. Stem girth (cm) of maize as influenced by integrated levels of potassium and zinc

Treatments	R-I	R-II	R-III	Mean
No Potassium + No Zinc (Control)	2.52	2.49	2.50	2.51 f
Potassium @ 40.0 kg ha^{-1}	3.06	3.03	3.04	3.05 cd
Potassium @ 60.0 kg ha^{-1}	3.23	3.17	3.18	3.20 c
Zinc @ 5.0 kg ha^{-1}	2.67	2.66	2.67	2.67 ef
Zinc @ 10.0 kg ha^{-1}	2.86	2.82	2.83	2.84 de
Potassium @ 40.0 kg ha^{-1} + Zinc @ 5.0 kg ha^{-1}	3.40	3.46	3.47	3.45 b
Potassium @ 40.0 kg ha^{-1} + Zinc @ 10.0 kg ha^{-1}	3.94	3.90	3.84	3.89 a
Potassium @ 60.0 kg ha^{-1} + Zinc @ 5.0 kg ha^{-1}	4.01	4.21	3.91	4.04 a
Potassium @ 60.0 kg ha^{-1} + Zinc @ 10.0 kg ha^{-1}	3.67	4.41	4.21	4.10 a

Means not sharing the same letter in a column differ significantly at 0.05 probability level.

SE±	0.1148
LSD $_{0.05}$	0.2433
LSD $_{0.01}$	0.3352
CV%	4.26

Biomass weight plant-1 (g)

The results pertaining to biomass weight plant-1 (g) of maize as influenced by different integrated levels of potassium and zinc are presented in Table-7 and their analysis of variance as Appendix-VII. The analysis of variance showed that various levels of potassium and zinc either sole or integrated affected positively and significantly (P<0.05) maize biomass weight plant-1 (g) as compared to No Potassium + No Zinc (Control).The data indicated that integrated application of Potassium @ 60.0 kg ha-1 + Zinc @ 10.0 kg ha-1 resulted in maximum biomass weight plant-1 (520.79 g) of maize, closely followed by Potassium @ 60.0 kg ha-1 + Zinc @ 5.0 kg ha-1 and Potassium @ 40.0 kg ha-1 + Zinc @ 10.0 kg ha-1 with biomass weight plant-1 of 517.90 and 515.16 g, respectively showing the non-significant (P>0.05) differences of above treatments with each other. The maize biomass weight plant-1 reduced to 504.79, 385.79, 346.12, 296.46 and 261.79 g in plots receiving Potassium @ 40.0 kg ha-1 + Zinc @ 5.0 kg ha-1, Potassium @ 60.0 kg ha-1, Potassium @ 40.0 kg ha-1, Zinc @ 10.0 kg ha-1 and Zinc @ 5.0 kg ha-1, respectively. However, minimum biomass weight plant-1 (209.12 g) of maize was recorded in plots receiving No Potassium + No Zinc (Control). The overall data suggested that sole application of potassium and zinc also demonstrated significant effects on biomass weight plant-1 (g) of maize as compared to control plot but the integrated application of potassium and zinc was more effective than their sole application.

Table 7. Biomass weight plant^{-1} (g) of maize as influenced by integrated levels of potassium and zinc

Treatments	R-I	R-II	R-III	Mean
No Potassium + No Zinc (Control)	200.79	209.79	216.79	**209.12 g**
Potassium @ 40.0 kg ha^{-1}	340.79	345.79	351.79	**346.12 d**
Potassium @ 60.0 kg ha^{-1}	382.79	376.79	397.79	**385.79 c**
Zinc @ 5.0 kg ha^{-1}	254.79	263.79	266.79	**261.79 f**
Zinc @ 10.0 kg ha^{-1}	295.79	294.79	298.79	**296.46 e**
Potassium @ 40.0 kg ha^{-1} + Zinc @ 5.0 kg ha^{-1}	502.79	500.79	510.79	**504.79 b**
Potassium @ 40.0 kg ha^{-1} + Zinc @ 10.0 kg ha^{-1}	505.16	514.16	526.16	**515.16 a**
Potassium @ 60.0 kg ha^{-1} + Zinc @ 5.0 kg ha^{-1}	507.90	516.90	528.90	**517.90 a**
Potassium @ 60.0 kg ha^{-1} + Zinc @ 10.0 kg ha^{-1}	510.79	519.79	531.79	**520.79 a**

Means not sharing the same letter in a column differ significantly at 0.05 probability level.

SE±	3.4314
$LSD_{0.05}$	7.2743
$LSD_{0.01}$	10.022
CV%	1.06

Green fodder yield (t ha-1)

The results pertaining to green fodder yield (t ha-1) of maize as influenced by different integrated levels of potassium and zinc are presented in Table-8 and their analysis of variance as Appendix-VIII. The analysis of variance showed that various levels of potassium and zinc either sole or integrated affected positively and significantly (P<0.05) maize green fodder yield (t ha-1) as compared to No Potassium + No Zinc (Control).The data indicated that integrated application of Potassium @ 60.0 kg ha-1 + Zinc @ 10.0 kg ha-1 resulted in maximum green fodder yield (41.53 t ha-1) of maize, closely followed by Potassium @ 60.0 kg ha-1 + Zinc @ 5.0 kg ha-1 and Potassium @ 40.0 kg ha-1 + Zinc @ 10.0 kg ha-1 with green fodder yield of 38.90 and 38.12 t ha-1, respectively showing the non-significant (P>0.05) differences of above treatments with each other. The maize green fodder yield reduced to 34.54, 24.39, 20.69, 15.76 and 14.79 t ha-1 in plots receiving Potassium @ 40.0 kg ha-1 + Zinc @ 5.0 kg ha-1, Potassium @ 60.0 kg ha-1, Potassium @ 40.0 kg ha-1, Zinc @ 10.0 kg ha-1 and Zinc @ 5.0 kg ha-1, respectively. However, minimum green fodder yield (11.85 t ha-1) of maize was recorded in plots receiving No Potassium + No Zinc (Control). The overall data suggested that sole application of potassium and zinc also demonstrated significant effects on green fodder yield (t ha-1) of maize as compared to control plot but the integrated application of potassium and zinc was more effective than their sole application.

Table 8. Green fodder yield (t ha^{-1}) of maize as influenced by integrated levels of potassium and zinc

Treatments	R-I	R-II	R-III	Mean
No Potassium + No Zinc (Control)	10.45	13.17	11.94	**11.85 g**
Potassium @ 40.0 kg ha^{-1}	21.03	20.37	20.67	**20.69 d**
Potassium @ 60.0 kg ha^{-1}	27.74	22.89	22.53	**24.39 c**
Zinc @ 5.0 kg ha^{-1}	15.93	12.69	15.75	**14.79 f**
Zinc @ 10.0 kg ha^{-1}	17.85	14.74	14.69	**15.76 e**
Potassium @ 40.0 kg ha^{-1} + Zinc @ 5.0 kg ha^{-1}	32.07	35.84	35.70	**34.54 b**
Potassium @ 40.0 kg ha^{-1} + Zinc @ 10.0 kg ha^{-1}	39.00	37.32	38.04	**38.12 a**
Potassium @ 60.0 kg ha^{-1} + Zinc @ 5.0 kg ha^{-1}	39.78	38.10	38.82	**38.90 a**
Potassium @ 60.0 kg ha^{-1} + Zinc @ 10.0 kg ha^{-1}	42.41	40.73	41.45	**41.53 a**

Means not sharing the same letter in a column differ significantly at 0.05 probability level

SE±	1.3112
$LSD_{0.05}$	2.7797
$LSD_{0.01}$	3.8299
CV%	5.96

Discussion

Fertilizer application with optimum doses is considered one of the major factors which can enhance the fodder production (Ali et al., 2012). Potassium is required in the greatest amount by maize. The demand for potassium is particularly large in the period of rapid growth and the crop needs to take up about 8 kg K2O ha 1 day-1. Potassium plays an important role in regulating the water content of the plant and with an adequate supply of K plants can survive drought stress more easily. It is essential for the transport of sugar from the leaves to the storage organs where the sugar is converted to starch. It plays a major role in maintaining the turgor of plant tissue. Among micronutrients, maize is especially sensitive to zinc deficiency. Zinc fertilization increases both nitrogen uptake and yield of maize. Different nutrients may interact with Zn by affecting the availability of each other from soils and their status in the plant through the process of growth or absorption, distribution and utilization. Application of potassium and zinc demonstrated significant enhancement in the fresh and dry weight of maize. The results indicated that all the doses of potassium and zinc either alone or in integration with each other affected positively and significantly ($P<0.05$) seed germination, growth and fodder yield traits of maize variety Agaiti-2002 over No Potassium and Zinc (Control). Integrated application of Potassium @ 60.0 kg ha-1 + Zinc @ 10.0 kg ha-1 resulted in maximum plant population (9.00 m-2), plant height (180.67 cm), nodes plant-1 (5.91), green leaves plant-1 (15.89), leaf length (48.55 cm), stem girth (24.73 cm), biomass weight plant-1 (520.79 g) and green fodder yield (41.53 t ha-1), followed by integration of Potassium @ 60.0 kg ha-1 + Zinc @ 5.0 kg ha-1, whereas minimum attributes were recorded in No Potassium and Zinc (Control). The higher growth and fodder yield traits of maize under integrated application of potassium and zinc at higher rates were possibly due to optimum availability and uptake of required nutrients at optimal concentration. The results are in line with the findings of Majlesy et al. (2012) who found that application of potassium and zinc showed marked increase in the fresh weight and dry weight of maize. In another study, Mahdi (2012) reported that zinc at 10 kg ha-1 markedly enhanced the plant height, leaf area index, dry matter production, chlorophyll content and number of functional leaves plant-1 of maize as compared to no zinc application. Stem diameter, leaf-stem ratio, green and dry fodder yield also increased significantly with zinc application @ 10 kg ha-1. Similarly, potassium fertilization significantly increased total yield of maize (Salimi et al., 2012). Zinc fertilization increased both nitrogen uptake and yield of maize (Sajedi and Ardakani, 2008). The results of this study are also in accordance with the findings of Tabrizi et al. (2011) who suggested that zinc had greatest impact on growth and yield of maize. In another study, Maqsood (2009) reported that with the application of potassium growth response of maize in terms of plant height and total biomass varied significantly compared to the control. It was found that fertilization with potassium improved the crop growth and biomass yield of maize. In a study, Nanjundappa and Manure (2002) assessed the response of fodder maize to fertilizer applications of nitrogen and potash and concluded that the application of N and K at the rate of 150 kg N ha-1 and 50 kg K2O ha-1 helps in increasing the dry fodder yield of fodder maize. The results of this study are supported with those of Osundare et al. (2008) who concluded that potassium substantially improved maize leaf area from 0.33 m2 plant¬1 for control to 0.60, 0.86, 1.05 and 1.19 m2 plant-1 for 100, 200, 300 and 400 kg K ha-1, respectively. Similarly, Barlog and Pawlak (2008) revealed that maize response to potassium fertilization depended on the vegetation season. In the year favorable for the establishment of a high maize yield, simultaneous potassium and magnesium fertilization @ 150 and 16.3 kg ha-1 induced a significant yield increase. The influence of zinc fertilization on yield depended both on the vegetative period and cultivar. In another study Saleem et al. (2006) found that different fertilizer levels played a significant role in boosting up the growth and yield parameters of maize. Potassium @ 275 kg ha-1 produced the highest leaf area (699 cm2) and yield efficiency ratio.

Conclusion

The results concluded that various levels of potassium and zinc either sole or integrated influenced positively and significantly ($P<0.05$) growth and fodder yield traits of maize as compared to No Potassium + No Zinc (Control). The integrated application of Potassium @ 60.0 kg ha-1 + Zinc @ 10.0 kg ha-1 produced maximum values for almost all the traits studied, particularly green fodder yield (41.53 t ha-1), closely followed by integrated application of Potassium @ 60.0 kg ha-1 + Zinc @ 5.0 kg ha-1 and Potassium @ 40.0 kg ha-1 + Zinc @ 10.0 kg ha-1 with 38.90 and 38.12 t ha-1 green fodder yield. Moreover, the integration of Potassium @ 40.0 kg ha-1 + Zinc @ 10.0 kg ha-1 proved to be the most promising and economical treatment for obtaining optimum green fodder yield of maize due to having non-significant ($P>0.05$) differences with other two treatments above.

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