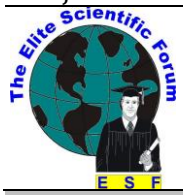
Pak. j. life soc. Sci. (2016), 14(2): 96-103 E-ISSN: 2221-7630;P-ISSN: 1727-4915



Pakistan Journal of Life and Social Sciences
www.pjlss.edu.pk

RESEARCH ARTICLE

Effect of Nursery Bulb Size and Planting Density on Thrips Population, Plant Height and Yield of Onion (Phulkara Variety) in Bahawalpur, Pakistan

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ARTICLE INFO
Received: Nov 22, 2015
Accepted: Jul 19, 2016
Online: Jul 25, 2016

Keywords
Allium cepa
Cultural practices
Economic benefits
Management
Resources

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ABSTRACT

There is dearth of knowledge to improve the sustainable productivity of onion crop. Present study investigates the effect of transplanting time, nursery bulb size and plant spacing on thrips population, plant height and onion yield under agro-climatic conditions of Bahawalpur, Pakistan. Experiment was laid out in a randomized complete block design with split plot arrangement with planting density as main factor and bulb size as sub-factor. There were three replications for the experiment. In general, results showed that thrips population, plant heights and final yield of onion bulb were greater due to medium planting density when plants were spaced at 6 inches as compared to less or more planting density (4 or 9 inches distance between plants). Effect of age of nursery bulb (bulb size) at transplanting showed that thrips population, plant heights and final yield was significantly more due to large bulb size (45-60mm) followed by medium bulb size (30-45mm); and least number of thrips, plant heights and onion yield was due to small bulb size (15-20mm) ($P<0.05$). Interactive studies showed that the large bulb size and medium planting density resulted in more population of thrips i.e. 11.83/plant and 5.88/plant in plots in early and late transplanting, respectively. However, in second transplanting, more thrips population was 13.81/plant due to large bulb size and least planting density. Similarly, more plant heights were resulted due to large bulb size and medium planting density. In early and mid-transplanting highest yield was recorded in plots with medium planting density and large bulb size i.e. 19470.52 and 6976.52 kg ha^{-1}, respectively. In general correlation between thrips population and plant height and between plant height and yield was positive however there was generally a negative correlation found between thrips population and yield. Finally, these results show that onion seedlings transplanted with large bulb size and planted at medium distance in the field resulted in more height of plants, more thrip population and also more yield of onion.

INTRODUCTION

Onion (*Allium cepa* L.) is one of the most important vegetables widely used in all households of the world. It belongs to the family amaryllidaceae and is so far the most important of the bulb crops. It is consumed at its young green stage or after its full development and maturity when it is harvested in the form of a dry bulb. Pakistan produces about 2 million tons of onion annually (FAO, 2012). It is one of the richest source of flavonoids as well as phosphorus, calcium and carbohydrates in the human diet which may play a part as antioxidant in preventing heart disease and other ailments (Abdulsalam and Hamaiel 2004; Ostrowska et al., 2004). Flavonoids are not only anti-cancer but also are known to be anti-bacterial, anti-allergenic, anti-viral

and anti-inflammatory (Ly et al., 2005; Nuutila et al., 2003; Prakash et al., 2007).

Onion cultivation is carried out in wet seasons and dry seasons, June to October and December to May respectively. Different cultural practices, growing environment as well as the insect pests and diseases are known to influence the yield of Onion (Fournier et al., 1995; Melander and Rasmussen, 2001; Shiberu and Mahammed, 2015). So far the research in the country has been focused on finding of important cultivar of onion and adopting improved cultural practices. The control of plant spacing is a way of ruling bulb yield. Studies on plant density suggested that the intra row spacing of 4 cm for 'Nasik' red and Adama red verities and 6 cm for Bombay may attain the highest marketable yield and reduced unmarketable bulb (Kashay et al., 2013). Varieties as well as pant density significantly affect the onion yield (Tendaj et al., 2002).

As onion is planted through nursery transplants therefore effect of nursery bulb size and transplanting date on growth and final yield of onion can be much more. Studies were conducted to investigate the effect of nursery bulb size and transplanting dates on growth and yield of onion (Asaduzzaman, 2015). It was reported that large mother bulb size and early transplants gave highest bulb and seed (Ud-Deen, 2008).

Thrips (Thysanoptera; Thripidae) is considered a serious insect pest of onion crop in central onion growing regions of Asia. Damage done by thrips is very incompensating on onion crops. Onion Thrips, *Thrips tabacii* are immeasurably small and have about 5000 species. It can cause serious damage in onion. Fournier et al. (1995) stated that strength of thrips population is easily controlled by different sowing dates and has correlation with environmental conditions (Fournier et al., 1995). It is the best way to control the onion thrips population. The thrips population is directly proportional to temperature and has inverse effect to humidity to some extent. The optimum temperature for the better growth of onion crop is 29 ^{o}C. So it causes serious infestation in cold dry climate to onion crop (Ibrahim and Adesiyun, 2009a; Ijoyah et al., 2009).Keeping in view the importance of cultural regimes for onion production like plant spacing in the field, effect of nursery bulb size for crop transplantation on the factors like plant heights, insect pest attack *i.e.*, thrips infestation and final yield of onion, this study rests on investigations regarding plant height, thrips population and final yield of onion under the effect of mother (nursery) bulb size and plant spacing checked from early to late transplanting in the season.

MATERIALS AND METHODS

Experiment was conducted in the field of the Islamia University of Bahawalpur during 2014-2015. The experimental plot was prepared by using rotavator and all clods of soil were broken by using planker. Weeds and stubbles of previous crops were removed completely. First we grew the nursery. Then we transplanted the seedlings of onion, *Allium cepa*. First nursery sowing was done on 1st October 2014 and nursery sowings were continued with the difference of each ten days. Overall there were nine sowings of nursery for this experiment to get mother bulb size difference. The first transplantation was done on 26 December, 2014, second transplantation was on 15 January, 2015 and third transplantation was on 11 March, 2015. The size of one block was 1.5m×1.3m, where seedlings were transplanted. Non-experimental area or empty space between two blocks was 2 feet.

Plants from nursery were selected for transplanting with bulb sizes ranging from 15-30 mm, 30-45 mm and 45-60 mm. Plant to plant distance was maintained as 4 inches, 6 inches and 9 inches respectively. Area of one transplanting was 539.56 sq feet.

Experiment was conducted in randomized complete block design with split plot arrangement with planting density as main factor and bulb size as sub-factor. There were three replications. Following transplanting of onion seedlings, fields were irrigated using the canal water system and subsequent irrigations were done based on soil conditions usually on weekly basis.

The first data was recorded after two weeks of transplanting when the seedlings started to produce new leaves. Data were taken from 10 randomly selected plants from one block, 30 plants from each replication and 90 plants from each treatment. We investigated planting density and bulb size for thrips population, plant heights as well as the final yield checked from early to late in the season.

For thrips data we selected ten plants randomly from each block. Then each plant was shaken on the white sheet paper card board, and then counted the number of thrips through visual counting and recorded the population. For plant height we used inches tape and for measurement of bulb diameter Vernier scale was used. Data were recorded throughout the season until the crop was harvested.

For yield parameters all the fruit were harvested from each unit plot. Roots as well as the leaves from harvested bulbs were removed when most of the leaves turned yellow and after attaining of full size of bulbs and bulbs were weighed using electrical weighing balance immediately before curing and bulb yield was converted in to kg acre^{-1} as well as kg ha^{-1}.

Statistical analysis

The results were analyzed by using the analysis of variance techniques and least significant difference test (LSD) was used to check the differences among the various treatment means (Steel et al. 1997). Treatments comprised planting density and nursery bulb size as independent factors while thrips population, plant height and yield were the dependent factors. Correlation

was also performed between plant height and yield, plant height and thrips population and between thrips population and yield of onion using Statistix 8.1 statistical software.

RESULTS

Thrips population per plant did not vary significantly with respect to planting density of onion seedlings in different transplanting in the season (Table 1, P>0.05). In first and third transplanting mean numbers of thrips were found maximum on plants with 6″ plant to plant distance (medium density) followed by 9″ and 4″ plant spacing respectively in early transplanting however in third transplanting second highest population of thrips was recorded on plants with 4″ planting distance (highest planting density) and least number of thrips were on plants with 9″ plant to plant spacing (least planting density). During the mid-season transplanting, higher population of thrips was on plants with 9″ plant to plant distance (least planting density) followed by 4″ (highest planting density) and least population was in plants due to 6″ planting distance (medium density) (Table 1, P>0.05).

Height of onion plants did not vary significantly with respect to planting density in different transplanting in the season. However maximum mean heights of plants in all of the three transplanting were found in plants with 6″ plant to plant distance (medium planting density) but with no significant difference between mean plant heights (Table 1, P>0.05). Second more height of plants in early transplanting was in least planting density and least heights were due to highest planting density.

In the mid and third transplanting second more heights of plants were in plants with highest planting density and least heights of plants were due to least planting density (Table 1, P>0.05).

Different plant spacing affected the yield of onion significantly (Table 1, P<0.05) in early, mid and late transplanting in the season. The data showed that in early and mid-transplanting, maximum onion bulb yield was recorded in the plants with the medium planting density with 6″plant spacing in the field followed by the highest plating density (4″ plant spacing) and significantly less yield was in plants with lowest planting density with 9″ plant spacing (Table 1, P<0.05). In late transplanting, highest yield was in plants was due to highest planting density with 4″ plant spacing followed by medium density of plants and least yield was in plant with least planting density of 9″ plant spacing between plants with significant difference between means yields (Table 1, P<0.05).

Thrips population varied significantly with respect to different sizes of bulb of transplanted seedlings in early transplanting in the season but a non-significant variation in thrips population was observed in mid and late season transplanting. Maximum mean number of thrips was recorded on seedlings of large bulb size followed by medium size and minimum number of thrips was found on seedlings with small bulb size (Table 2, P<0.05).

Heights of onion plants varied significantly with respect to sizes of bulb of nursery transplants. Maximum mean height of onion plants was recorded on seedlings of large bulb size followed by medium size and minimum height of plants was found on seedlings with small bulb size (Table 2, P<0.05).

Yield results showed that larger bulb size group of nursery transplants produced comparatively higher bulb yield per ha^{-1} at the harvest followed by medium size and least and significantly less yield was due to smaller bulbs of nursery transplants group (Table 2, P<0.05).

Thrips population did not vary significantly due to interaction between bulb size and planting distance in onion crop from early to late transplanting in the season. However maximum mean number of thrips was (11.83) in early transplanting found on seedlings transplanted with large bulb size group and medium planting density and minimum number of thrips (6.72) were recorded due to small bulb size and highest planting density (Table 3, P>0.05). In second transplanting, more population of thrips (13.81) was due to large bulb size and least planting density and least population of thrips (4.82) was due to small bulb size and medium planting density. In third transplanting more population of thrips (5.88) was due to large bulb size and medium planting density and least population (3.86) was due to small bulb size and medium planting density (Table 3, P>0.05).

Height of onion plants (cm) did not vary significantly due to interaction between bulb size and planting distance. However maximum mean height of plants in first transplanting was (16.03) found on seedlings transplanted with large bulb size with medium planting density and lowest heights of plants was (13.36) due to small bulb size and least planting density. In the second transplanting maximum heights of plants was (13.59) due to large bulb size and medium planting density and lowest heights of plants was (8.55) due to small bulb size and highest planting density. In the third transplanting, maximum heights of plants was (11.06) due to small bulb size and highest planting density and lowest heights of plants was (6.45) due to large bulb size and least planting density (Table 3, P>0.05).

Yield of onion bulb was converted in to kilogram per acre as well as per hectare. Maximum yield per hectare in first transplanting was (19470.52 kg) with large bulb size and a medium planting density and minimum yield was recorded as (10629.64 kg) with small bulb size and least planting density (9 inches plant to plant distances) with no significant difference between means. Similar

Table 1: Comparisons of thrips (Thysanoptera: Thripidae) population, plant height and yield from early to late in the season in relation to planting density in Onion crop

Treatment	Thrips population			Plant height (cm)			Yield					
	early	mid	Late	early	mid	late	early		mid		Late	
							(kg/acre)	(kg/hac)	(kg/acre)	(kg/hac)	(kg/acre)	(kg/hac)
D1	7.36[a]	7.76[a]	4.85[a]	14.39[a]	10.81[a]	8.69[a]	7077.6[a]	17481.7	2115.5[a]	5225.28	1746.0[a]	4312.62
D2	9.93[a]	6.39[a]	5.00[a]	15.13[a]	11.64[a]	8.87[a]	7366.3[a]	18194.8	2335.3[a]	5768.19	1165.5[b]	2878.78
D3	7.88[a]	9.75[a]	4.18[a]	14.79[a]	10.80[a]	8.33[a]	5550.0[b]	13708.5	1340.5[a]	3311.03	990.7[b]	2447.03
F	1.5	2.39	0.57	1.01	1.06	0.44	11.06		41.47		14.19	
P	0.2259	0.0953	0.5692	0.3674	0.3505	0.6428	0.0003		0		0.0012	
LSD	3.0972	3.0972	1.16116	1.0273	1.3232	1.1719	847.82		255.69		330.69	

D1: 4 inches plant to plant spacing, D2: 6 inches plant to plant spacing, D3: 9 inches plant to plant spacing

Table 2: Comparisons of thrips (Thysanoptera: Thripidae) population, plant height and yield from early to late in the season in relation to bulb size in Onion crop

Treatment	Thrips population			Plant height (cm)			Yield					
	early	mid	Late	early	mid	late	early		mid		Late	
							(Kg/acre)	(Kg/ha)	(Kg/acre)	(Kg/ha)	(Kg/acre)	(Kg/ha)
B1	7.54[b]	5.82[a]	4.04[a]	13.68[b]	9.16[c]	7.01[c]	5873.2[b]	14506.8	1432.9[b]	3539.26	944.9[b]	2333.91
B2	7.75[ab]	7.93[a]	4.70[a]	14.87[a]	11.14[b]	8.66[b]	6962.4[a]	17197.1	2132.1[a]	5266.28	1347.4[ab]	3328.07
B3	9.87[a]	10.15[a]	5.31[a]	15.77[a]	12.95[a]	10.23[a]	7158.3[a]	17681	2226.3[a]	5498.96	1610 .0[a]	3976.7
F	14.07	3.21	4.89	14.99	48.09	93.54	4.42		3.48		4.83	
P	0.0155	0.1475	0.0843	0.0139	0.0016	0.0004	0.0422		0.0437		0.0152	
LSD	1.3491	4.742	1.1283	1.0643	1.0735	0.6525	1038		671.06		440.08	

B=Bulb size, cm=Centimeter

results were also found for second transplanting in which maximum yield per hectare was (6976.52 kg) with large bulb size and a medium planting density and minimum yield was recorded as (2486.54 kg) with small bulb size and least planting density with no significant difference between means (Table 3, $P > 0.05$). In third transplanting maximum yield per hectare was (6170.55kg) with small bulb size and least planting density and minimum yield was recorded as (1773.71kg) with medium bulb size and highest planting density and with significant difference between means (Table 3, $P < 0.05$).

Correlation of factors under study revealed positive correlation between thrips population and plant heights except in second transplanting where correlation between thrips population and plants heights was negative. Correlation between thrips population and yield is negative except in 2nd transplanting where slight positive correlation was found between the two factors. Correlation between plant heights and yield of onion were positive in all three transplanting (Table 4).

DISCUSSION

Present study investigated the effect of three groups of bulb sizes of nursery transplants (15-30 mm, 30-45 mm and 45-60 mm) and three planting distances (4″, 6″ and 9″) to check their effect on thrips population, plant height and yield of onion bulb at harvesting. Interactive effects were also observed between bulb sizes and planting distances to see their effect on thrips population, plant height and yield of onion bulb. Nursery seedlings were transplanted three times from early to late in the season to see the effect of these factors on dependent variables from early to late transplanting of onion seedling in the season.

Results showed that number of plants per plot or the plant to plant distance did not affect significantly per plant thrips population. However, mean number of thrips per plant were more in plants with 6″ plant to plant distance in early and late transplanting and in second transplanting highest population of thrips per plant was on plants with 9″ plant to plant distance (least planting density per plot). Plant heights did not vary significantly with planting density in the plots. However, plant heights were more for plants with medium planting density from early to late transplanting in the season. Plants had relatively smaller heights with either more or less planting density in plots.

Yield was measured in term of bulb weight at harvesting. Yield was significantly affected by planting density. Highest yield was recorded in plots with medium planting density followed by highest planting density with no significant difference between the two yields while least and significantly less yield was with lowest planting density in early transplanting. Same results were obtained in second transplanting. Similarly, in third transplanting highest yield was recorded in highest planting density followed by medium planting density and least yield was in lowest planting density. Dawar et al. (2007) conducted a study to see the effect of planting density on growth and yield of onion varieties under climatic conditions of Peshawar, Pakistan. They found that maximum yield (7958 kg ha^{-1}) was

Table 3: Comparisons of thrips (Thysanoptera: Thripidae) population, plant height and yield from early to late in the season on onion for the interaction between bulb size and planting density

Treatment	Thrips population			Plant height			Yield					
	early	mid	late	early	mid	late	early		mid		late	
							(kg acre^{-1})	(kg ha^{-1})	(kg acre^{-1})	(kg ha^{-1})	(kg acre^{-1})	(kg ha^{-1})
D1S1	6.72^{a}	7.14^{a}	4.54^{a}	13.39^{a}	8.55^{a}	11.06^{a}	6394.10^{a}	15793.42	1561.10^{a}	3855.92	1005.00^{bc}	2482.35
D1S2	7.32^{a}	6.79^{a}	4.93^{a}	14.49^{a}	11.14^{a}	9.12^{a}	7336.50^{a}	18121.15	2451.50^{a}	6055.21	718.10^{c}	1773.71
D1S3	8.04^{a}	9.35^{a}	5.08^{a}	15.30^{a}	12.74^{a}	7.55^{a}	7502.20^{a}	18530.43	2333.80^{a}	5764.48	1111.70^{bc}	2745.89
D2S1	8.76^{a}	4.82^{a}	3.80^{a}	14.27^{a}	9.35^{a}	9.82^{a}	6922.00^{a}	17097.34	1730.70^{a}	4274.83	1735.00^{b}	4285.45
D2S2	9.21^{a}	7.08^{a}	5.25^{a}	15.09^{a}	11.10^{a}	8.71^{a}	7294.20^{a}	18016.67	2450.60^{a}	6052.98	1356.30^{bc}	3350.06
D2S3	11.83^{a}	7.28^{a}	5.88^{a}	16.03^{a}	13.59^{a}	7.04^{a}	7882.80^{a}	19470.52	2824.50^{a}	6976.52	950.90^{c}	2348.72
D3S1	7.16^{a}	5.52^{a}	3.70^{a}	13.36^{a}	9.58^{a}	9.79^{a}	4303.50^{a}	10629.64	1006.70^{a}	2486.54	2498.20^{a}	6170.55
D3S2	6.74^{a}	9.92^{a}	3.90^{a}	15.02^{a}	10.28^{a}	8.10^{a}	6256.60^{a}	15453.8	1494.30^{a}	3690.92	1422.30^{bc}	3513.08
D3S3	9.76^{a}	13.81^{a}	4.95^{a}	15.97^{a}	12.53^{a}	6.45^{a}	6089.80^{a}	15041.81	1520.50^{a}	3755.63	909.60^{c}	2246.71
F	0.12	0.98	0.19	0.16	0.47	0.78	0.63		0.19		2.75	
P	0.9758	0.4216	0.941	0.9569	0.7552	0.5371	0.6445		0.9393		0.0462	
LSD	5.3644	5.2859	2.7914	1.7794	2.2918	2.0299	1468.5		1162.3		704.33	

B=bulb size, D=plant distance, cm= centimeter

Table 4: Correlation between the thrips population and plant height, thrips population and yield and plant height and yield from early to late sowing in onion crop

Treatment	Transplanting time					
	early		mid		Late	
	r	*p value*	*r*	*p value*	*r*	*p value*
Thrips population and plant height	0.1393	0.3153	-0.2912	0.0327	0.4408	0.00080
Thrips population and yield	-0.1145	0.4095	0.0193	0.8898	-0.0669	0.63070
Plant height and yield	0.2349	-0.0874	0.3472	0.0101	0.1067	0.44270

produced by a variety Terich-02 at a density of 80 plants/4m^2 which was the highest density of onion plants per unit area compared with other two densities under study. These results are similar to our study which shows that a relatively higher planting density per plot yielded greater yield. We had the highest yield 18194.8 kg per hectare and 5768.19 kg per hectare respectively in first and second transplanting with medium planting density than with lower planting density and in third transplanting yield was 4312.62 kg per hectare as higher yield with highest planting density. These results show the overall weight of onion bulbs similar to that of Dawar et al. (2007) which showed yield of onion bulb was significantly affected by planting density in the field. It has been reported that maximum yield can be obtained by maintaining optimum plant population according to plant morphological characteristics. Khan et al. (2003) studied the effect of six plant spacing on yield of onion and individual growth and bulb yield parameters. Results revealed that total yield was highest with closest plant spacing compared with wider spacing of plants however individual plant growth parameters and single bulb size was highest due to wider spacing of plants compared with closer spacing. These results are comparable to our results that showed more total yield was highest in medium plant spacing than in wider plant spacing. Plant heights were more with medium planting density of onion plants in the field. These results are relatively similar to that of Saud et al. (2013). They conducted a study to check the effect of potassium levels and row spacing in onion for their effects on plant growth and yield. They found that with maximum level of potassium and medium or greater row spacing, growth related factors like plant heights and yield of onion were also greater than that from lower potassium level and closer row spacing. Jilani et al (2010) checked the effect of plant spacing on growth and yield of two varieties of onion under agro-climatic conditions of Dera Ismail Khan, KPK Pakistan. They found that wider plant spacing improved plant growth parameters like plant height, number of leaves per plant bulb diameter and weight but this reduced yield per plot and total yield. Total yield was highest due to closed plant spacing. Mahadeen (2008) studied the effect of different transplanting dates and different plant spacing effect on yield of onion bulb in semi-arid conditions. They recorded greater bulb yield under the effect of early transplanting and with closest plant spacing.

Thrips population was more on plants with medium planting density. Thrips population was counted per plant. Greater population of thrips with medium planting density could be due to greater biomass *i.e.*, heights of plant were also greater in plots where plant spacing was medium. Thus insect pests like thrips were greater where they had comparatively more space for feeding and reproduction. Ibrahim and Adesiyun (2009b) studied the effect of age and height of onion on

infestation by thrips in onion. They found that oldest and tallest plants had highest thrips population.

Effect of bulb size of nursery seedlings showed that thrips population, plant heights and bulb yield was significantly affected due to bulb size range of three groups. Our results showed that greater the size of bulb of nursery transplants more was the thrips population per plant and heights of plants were also greater in seedlings transplanted with large size of bulbs. Similarly yield was also greater in plots with large size of onion bulbs of nursery transplants. A study was conducted to investigate the effect of bulb size and plant density on yield and quality of onion (*allium cepa* var cepa l) seed, at ziway, central Ethiopia by Zena (2008). Results showed largest umbel size was obtained from low plant density; whereas the smallest from high plant density. Maximum seed yield per 100 m^2 was collected from high density while low density yielded almost ten times smaller seeds per 100 m^2. However, the quality of seed in terms of germination was highest for seeds obtained from low density. The influence of bulb size was significant on plant height, number of flower stalks per plant, number seeded florets per umbel and other different factors. Plants grown from large bulbs produced plants with best height, highest number of flower stalks, seeded florets per umbel, seed per plant, seeds per 100 m^2 and seed yield. These results are similar to our studies that showed seedlings transplanted with large bulb size produced greater heights and significantly more yield than do smaller bulb or medium bulb seedlings. Similarly, more thrips were also noted on seedlings transplanted with large bulb. This should be due to fact that plants with large bulbs grew early and attained longer heights compared with other seedlings of medium or small bulb size and subsequently thrips per plant were more on plants with more heights. Ibrahim and Adesiyun (2009b) also stated that plants grown earlier and with tall heights had greater thrips infestation.

Interactive effects showed more population of thrips was in plots with large bulb size of transplants and medium planting density in early transplanting (11.83/plant). In second transplanting it was 13.81/plant due to large bulb size and least planting density. In third transplanting thrips population remained (5.88/plant) as highest due to interaction between large bulb size and medium plant spacing. Plant heights were 16.03 and 13.59 respectively in first and second transplanting due to interaction between large bulb size and medium planting density. In third transplanting plants height was maximum (11.06) due to interaction between small bulb size and highest planting density. Plant spacing effect in interactive studies is also more in medium planting density relative to least or highest planting densities. More yield per hectare due to interaction between bulb size and plant heights was 19470.52 and 6976.52 respectively in first and second transplanting which were due to large bulb size and medium planting density. In third transplanting highest yield (6170.55) was due to interaction between small bulb size and least planting density which is contrary to results generated in first and second transplanting in which least yields were due to interaction between small bulb size and least planting density. It has been described that plant height decreases as plant population density increases. Total bulb yield increases significantly as population density increases and number of marketable bulbs increase significantly with higher planting density (Kanton et al. 2003).

Correlation of factors revealed that in first and third transplanting positive correlation was found between thrips population and plant height that shows thrips were greater in plots in which plant heights were more. However, in second transplanting a negative correlation was found that is reverse of first and third transplanting. We found a slight negative correlation between thrips population and yield in first and third transplanting but a very weak positive correlation exists between thrips population and yield in second transplanting. Negative correlation shows that plants with more thrips had less yield and vice versa. Correlation between plant height and yield showed positive correlation that shows plots with more plant heights generated more yield of onion bulbs. Study of correlation of factors support our previous discussion which state that planting density per plot affects amount of nutrition and water uptake by plants thereby more nutrition and water becomes available to plants with lower number of plants per unit area than with more plants per unit area which in turn face more competition between them to get the same resources. Insect pests like thrips are also more in plants with greater heights for they find more space and the result is that average number of thrips per plant is obviously more on plants with more heights. Thrips population is somewhat negatively correlated with onion yield that shows more thrips resulted in less onion yield and vice versa. Plant heights are positively correlated with onion yield. This shows that plants that grew tall were healthy compared with smaller plants and had more yield as well.

In all we saw that plant heights, yield and mean number of thrips per plant went on decreasing from early to late transplanting in the season. This could be due to high temperatures observed in Bahawalpur region. When temperature exceeds 30 ^oC particularly during night and due to this factor net photosynthesis and respiration stops and plant growth and yield is affected negatively as season progressed in this region. Mahadeen (2008) studied the effect of different transplanting dates and different plant spacing effect on yield of onion bulb in semi-arid conditions. They recorded greater bulb yield under the effect of early transplanting and with closest plant spacing.

Conclusion

These results suggest that best time of nursery transplanting of onion (Phulkara variety) in Bahawalpur region of Pakistan is last decade of December (early transplanting) than does in January or March. During mid and late season transplanting, onion growth and yield was affected drastically due to high temperature. Thrips population was more on plants with more height or growth; however, thrips had a weaker correlation with yield as pest. Medium planting density of 6 inches between plants and greater bulb size of 45-60mm resulted in better heights and yield in onion.

Authors' Contributions

This work was conducted by collaborative intellectual efforts of all authors.

Acknowledgements

The authors acknowledge the work done by Syed Muhammad Riaz and M. Uzair Arshad for contribution in data collection during experiments.

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