Research Article

Response of Onion Crop to Varying Cropping Patterns and Non-Chemical Weed Control Methods

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Abstract | An experiment was carried out at the research farm of the University of Agriculture, Peshawar in the Rabi season of 2014 in order to figure out the influence of different cropping patterns (sowing directions) and weed control practices on onion crop. A two factorial RCBD experimental design was used for the experiment replicated three times. Factor A was termed as the cropping pattern (or sowing direction) with two levels (i.e. North-South and East-West), while the factor B included the treatments of *Rumex crispus* as mulch, *Euphorbia helioscopia* as mulch, wheat straw as mulch, a hand weeded treatment and a weedy control. Data were taken on fresh weed biomass (kg ha^{-1}), plant height (cm), no. of leaves plant^{-1} and biological yield (kg ha^{-1}). The results of the investigation showed that both the cropping patterns and weed control measures significantly affected all the studied parameters except plant height at maturity (cm). Furthermore, the N-S sowing direction proved to be more effective in terms of weed control and enhancing the yield of onion crop. Among the weed control measures, hand weeding proved the best in terms of weed control and desirable onion yield. The weed fresh biomass was higher in the E-W sowing direction of onion crop (930 kg ha^{-1}) than in the N-S sowing direction (631 kg ha^{-1}). The weed biomass among the weed control treatments was highest (1003 kg ha^{-1}) in weedy check and lowest (561 kg ha^{-1}) in hand weeding. Similarly, higher no. of leaves plant^{-1} (7.6) and biological yield (13517 kg ha^{-1}) were obtained in the N-S sowing direction as compared to 6.53 and 12978 kg ha^{-1}, respectively in the E-W sowing direction. The mulch treatments of *R. crispus, E. helioscopia* and wheat straw had the weed biomasses of 765, 792, and 782 kg ha^{-1}, respectively. Among the factor B treatments, the highest values for the number of leaves plant^{-1} were in hand weeding (8.5 leaves) and lowest number plant^{-1} was in weedy check (5.7 leaves). The mulch treatments of *R. crispus, E. helioscopia* and wheat straw had an average of 7.0, 7.17, and 7.0 leaves plant^{-1}, respectively. The highest biological yield (15364 kg ha^{-1}) was recorded in the plots of hand weeding, while the lowest (11439) in the control. Mulch treatments of *R. crispus, E. helioscopia* and wheat straw had the biological yield of 13306, 13071 and 13059 kg ha^{-1}, respectively. In conclusion, the North-South cropping pattern (sowing direction) and the mulching of chopped biomass of *R. crispus* and *E. helioscopia* could be a best environment friendly weed management strategy and for yield enhancement of onion crop in Peshawar region.

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Introduction

Economy of Pakistan is mainly based on agriculture sector. The environmental conditions of Pakistan are conducive to grow a wide range of crops. However, production of most of the crops in Pakistan is lower as compared to the world's average (Khan, 2004). Various weeds infestation is one of the most important reasons for the lower yields of crops in the country. According to FAO (2006), onion (*Allium cepa* L.) is the world's one of the most important vegetable crop having about 61 m t total production in the world. Pathak (2000) is of the view that out of the 15 vegetables at FAO list, the total production of onion comes second after the tomato (which is at first rank). It is grown in almost all the districts of the Khyber Pakhtunkhwa, Pakistan covering irrigated and un-irrigated areas of 10157 and 823 ha, with total production of 170629 and 10624 tons, respectively (Anonymous, 2010-11).

Ghaffoor (2004) reported that the average onion yield is too low in Pakistan if compared to the rest of the leading countries. Out of the many factors weed infestation is a very important factor for onion yield reduction. Onions face strong competition from weeds for nutrients, space, light, and soil moisture which considerably diminish the onion yield, quality and crop value through increased cost of production and harvesting (Kizilkaya *et al.*, 2001). The weed based losses in yields have been reported to be very higher than the insect and disease based losses. Generally, weeds infestation reduces the crop yield by 30-60% (Hussain, 1983). Hand weeding is one of the key weed control method for marketable bulbs. Generally, the farmers do not apply weed control methods at the early stages of the crop to prevent major weed related damages. Furthermore, Melander and Rasmussen (2001) described that manual weeding is a time-consuming, laborious and expensive method of weed control, and even it may also damage the crop.

The slow growth in addition to shallow roots and thin canopy render onion seedlings poor weed competitors. Moreover, the cylindrical upright leaves have less shading capacity of the soil to block the weed emergence and growth (Bell and Boutwell, 2001). Several factors like present weed species, crop variety, growth stage of the crop, weed species, labor costs and availability etc. all play role together.

The lower yields are attributed to limited availability of good quality seeds and improved varieties (Ali *et al.*, 2007). Improved seed varieties would contribute to crop yield up to 30% (Shaikh *et al.*, 2002). The yield gap of 50–60% between potential and actual yield is also attributed to several agronomic constraints of which improper sowing methods and poor weed control practices are considered to be important ones (Ahmad, 1992). Also, soil moisture is one of the most important factors that influences onion yield. Onion requires frequent irrigation as the crop extract very little water from depths below 5 cm; most of the water is within the depth of 30 cm of the soil (Ali *et al.*, 2007).

Thus, to stimulate the root growth and also provide adequate water to the plant, upper soil areas should be kept moist. Using plant residues and synthetic materials as mulch is a well-established practice for soil moisture conservation and plant growth and development (Kashi *et al.*, 2004; Rhu *et al.*, 1990). There is another scope of manipulating the sowing directions in relation to sunlight that fall on the crop canopy. No proper research has yet been reported on this aspect. Therefore, it could make us discover the impact of sowing directions on the weeds and yield of the crop.

Keeping in view the above given reasons for lower yields of onion, an experiment is designed to figure out the impact of sowing directions and various mulches on weed growth and crop yield components.

Materials and Methods

The proposed experiment titled "Response of onion to varying cropping patterns and non-chemical weed control methods" was conducted at the Research Farm of the University of Agriculture, Peshawar during Rabi season 2014. The experiment was laid out in a two factorial RCB design having three replications. There were two transplanting directions as factor A. The two transplanting directions were north-south (N-S) and east-west (E-W). This means that the crop plants have sown in rows that are placed in two directions i.e., one in north-south direction and the other in east-west direction. The treatments in factor B were three mulches including wheat straw and biological material of two weeds i.e., *Rumex crispus* and *Euphorbia helioscopia*. A hand weeding treatment and a weedy check were included in the factor B treatments for comparisons. The size assigned for

each individual treatment will be 2m x 4m. Bulbs of onion variety were planted at a spacing of 15 x 25cm. The data was recorded on the following parameters:

1. Fresh weed biomass (kg ha^{-1})
2. Plant height at maturity (cm)
3. Number of leaves plant^{-1}
4. Biological yield of onion

Statistical analysis

Microsoft Excel was first used for the data analysis and the results were confirmed by using statistical software Statistix 8.1 version. The means of all the data are parameter wise displayed in the Tables 1, 2, 3 and 4.

Results and Discussion

Fresh weed biomass (kg ha^{-1})

Statistical analysis of the data declared that sowing directions and mulching treatments had a significant effect on the parameter of fresh weed biomass (Table 1). The mean values showed that weed biomass was higher (930 kg ha^{-1}) in plots where crop plants were sown in the east west direction, however the value in the north south direction plots was 631 kg ha^{-1}. The weedy check plots had the highest fresh weed biomass of 1003 kg ha^{-1} among the factor B treatments. Here the lowest biomass of 561 kg ha^{-1} was achieved in hand weeded plots. Hand weeding, which is though the best weed control treatment, increases the cost of production when free labor is not available. Similarly, it is always weather dependent which reduces the chances of success and timely application. Therefore, mulching of *R. crispus* and *E. helioscopia* remains the best option among the rest of the treatments. Then why should one go to the choice of herbicide application that aggravates the environmental hazards and health issues. In this connection, Baki *et al.* (1995) reported that mulching of hairy vetch reduced the weed germination and growth. One kg of weed mass will mean a loss of one kg of crop weight (Rao, 2000). The limited resources are shared equally by the weed and crop plants and as a result a reduction in crop yield and biological weight takes place.

The interaction effect was also significant. A lowest biomass of 372 kg was obtained in hand weeded plots under the north south sowing as compared to the weedy check 812 kg ha^{-1} under the same sowing direction. Table 1 shows further details.

Table 1: *Fresh weed biomass (kg ha^{-1}) as affected by sowing directions and different mulching materials.*

Treatments	Sowing directions		Mean
	North-South	East-West	
Rumex crispus as mulch	639.33bc	892.00ab	765.67ab
Euphorbia helioscopia as mulch	653.67bc	932.00ab	792.84ab
Wheat straw as mulch	680.00bc	884.00ab	782ab
Hand weeding	372.33c	751.00b	561.67b
Weedy check	812.00b	1195.33a	1003.67a
Mean	631.46b	930.86a	

Means followed by different letters are statistically different at 0.05 α level.

Plant height at maturity (cm)

Plant height is a very important parameter and is greatly affected by the confronting environment and the applied techniques. The data regarding plant height is presented in Table 2. Both the sowing directions and the weed control treatments had a non-significant effect on plant height of onion crop. However, an average of 2cm difference in plant height was found among the sowing directions. In addition, the range of plant height among the factor B treatments was 33 to 39 cm, in which the highest value was in weedy check and lowest in the hand weeding. This therefore indicated that competition with weeds in weedy check triggered the crop plants to go higher and utilize the resources for vegetative growth to capture the light for photosynthesis. Thus, the lower height in hand weeded plots was due to less competition with weeds that forced the supply of resources to the bulbs development rather than to the vegetative growth.

Table 2: *Plant height at maturity (cm) as affected by sowing directions and different mulching materials.*

Treatments	Sowing directions		Mean
	North-South	East-West	
Rumex crispus as mulch	37.67	35.00	36.4
Euphorbia helioscopia as mulch	35.67	35.33	35.5
Wheat straw as mulch	35.33	33.67	34.5
Hand weeding	34.67	32.33	33.5
Weedy check	40.67	37.33	39.0
Mean	36.8	34.73	

Means followed by different letters are statistically different at 0.05 α level.

The mulching effect was also non significant regarding the plant height. However, it is important

in the rest of the parameters. Many previous reports showed that mulching conserves soil moisture as well as provides desirable soil temperature thus promotes the vegetative growth of plant including onion plant height (Stowell, 2000; Mahajan *et al*., 2007).

Number of leaves plant^{-1}

Statistical analysis of the data stated that sowing directions and mulching treatments and their interactions had a significant effect on the number of leaves plant^{-1} of onion (Table 3). Data means indicated that the no. of leaves plant^{-1} of onion was lower (6.53 plant^{-1}) in the plots with sowing of crop plants in east west direction, however the value in the north south direction plots was higher (7.6 leaves plant^{-1}) comparatively. The hand weeding plots had the higher number of leaves (8.5 leaves plant^{-1}) among the factor B treatments. Here the less number of leaves (5.7 leaves plant^{-1}) was achieved in weedy check plots. All the other treatments indicated statistically comparable results. Weedy check had lowest number of leaves plant^{-1} which may be due to the competition with weeds. In competition with weeds, the no. of leaves is reduced but the height is increased in this study. The positive effect of mulching on number of leaves plant^{-1} observed in this trial agreed with the findings of John (1999) and Umar *et al*. (2000). As regards the mulching treatments, the *Euphorbia helioscopia* as mulch resulted in values statistically at par with the hand weeding treatment.

Table 3: *Number of leaves plant^{-1} as affected by sowing directions and different mulching materials.*

Treatments	Sowing directions		Mean
	North-South	East-West	
Rumex crispus as mulch	7.33 abc	6.67 bc	7 ab
Euphorbia helioscopia as mulch	8.00 ab	6.33 bc	7.17 ab
Wheat straw as mulch	7.33 abc	6.67 bc	7 ab
Hand weeding	9.33 a	7.67 ab	8.5 a
Weedy check	6.00 bc	5.33 c	5.7 b
Mean	7.6 a	6.53 b	

Means followed by different letters are statistically different at 0.05 α level.

The interaction effect was also significant. A less number of leaves 5.33 plant^{-1} was obtained in weedy check plots under the east west sowing as compared to the hand weeded number of leaves 9.33 plant^{-1} under the north south sowing direction. The overall range of no. of leaves plant^{-1} in the interaction factor ranged from 5.33 to 8.00 (Table 3).

Biological yield (kg ha^{-1})

The weight of the whole plant parts with bulb comes under the terminology of biological yield. The analysis of variance demonstrated that biological yield (kg ha^{-1}) was significantly affected by different sowing directions and mulches techniques. Means of the values showed that the biological yield was obtained higher (13517 kg ha^{-1}) in plots where crop plants were sown in the north south direction, and on the other hand the value in the east west direction plots was 12978 kg ha^{-1}, which was lower. As far as the mean data for different weed control treatments is concerned, it showed a maximum biological yield of 15364 kg ha^{-1} recorded in the hand weeding treatments which was though statistically at par with the mulch treatment (Table 4). The rest of the treatments were also statistically comparable with each other. However, minimum biological yield (11439 kg ha^{-1}) was generated in weedy check plots. The reason for the lowest biological yield in the control plots may be due to high competition of weeds with the crop that reduced the overall biomass of the crop. Consequently, the crop plants gained less amount of nutrients which adversely affected the biological yield of onion crop in weedy check plots. The natural resources like nutrients, space, water, light etc. always limited in field conditions due to which there takes place a strong competition for the resources between the weed and crop plants if they grow together. The conditions of a weedy check treatment are quite conducive for such situation. As a common sense when, when resources are limited and commonly shared by both the weed and crop plants then one kilogram of weed biomass produced in a field will mean a loss of one kilogram in crop biomass (Rao, 2000).

Table 4: *Biological yield (kg ha^{-1}) as affected by sowing directions and different mulching materials.*

Treatments	Sowing directions		Mean
	North-South	East-West	
Rumex crispus as mulch	13922 b	12690 cd	13306 b
Euphorbia helioscopia as mulch	13423 bc	12718 cd	13071 b
Wheat straw as mulch	12961 bc	13156 bc	13059 b
Hand weeding	15608 a	15119 a	15364 a
Weedy check	11673 de	11205 e	11439 c
Mean	13517 a	12978 b	

Means followed by different letters are statistically different at 0.05 α level.

As for the interaction of sowing directions and mulch treatments, the effect was significant where the highest biological yield of 15608 kg ha^{-1} in hand weeded plots under the north south sowing were recorded, compared to the weedy check where minimum biological yield of 11205 kg ha^{-1} was obtained under the east west sowing direction (Table 4).

Conclusions and Recommendations

The following conclusions have been made in light of the results obtained. The effect of the sowing direction and the treatments was significant on majority of the parameters. The north south sowing direction of the onion plants seems to be better than sowing in east west direction. In this regard, the fresh weed biomass was significantly lower in the cropping pattern of north south sowing. The biological yield of onion bulbs was also better in the north south sowing direction. Hand weeding performed the best in all parameters among the weed control treatments. However, it is impracticable on large scale. All the three mulching treatments of *Rumex crispus*, *Euphorbia helioscopia*, and wheat straw performed statistically similar to each other but better than the weedy check as regarding all the parameters.

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Novelty Statement

The combination of different cropping patterns, non-chemical weed control methods in onion crop in the agro-ecological conditions of Peshawar valley is a kind of innovative work. Such work has never been reported in onion crop in Peshawar region.

Author's Contribution

Luqman planned and conducted the experiment, Zahid Hussain supervised the research, Tamana Bakht and Sara Hidayat collected the data of the research, Fazli Wahab provided logistic support, Haroon Khan and Imran Shinwari analyzed the data, Miftah-ud-Din wrote the manuscript, Ata Ullah and Liaqat Khan did the literature searching for the manuscript write-up.

Conflict of interest

The authors have declared no conflict of interest.

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