

## Research Article



# Weeds Population Studies and Wheat Productivity as Influenced by Different Sowing Techniques and Herbicides

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**Abstract** | Weeds infestation is the serious problems of wheat crop of Pothwar Region in Pakistan. To find out the remedy of the said issues a field experiment was conducted at University Research Farm, Chakwal Road, Rawalpindi during 2015-16 to investigate the effect of different herbicides and sowing methods on wheat productivity and population dynamics of weeds. Different wheat sowing methods (S) were Broadcasting, Line sowing, Ridge sowing, Bed sowing and herbicides used were Ally Max, Clean wave, Starane M. and Buctril Super 60 Ec. The experiment was laid out in RCBD with split plot arrangement having three replications. Hand weeded (weed free), and weedy check (control) plots were also maintained for comparison in each replication. The recorded data were analyzed using Fishers analysis of variance technique and means were compared by using the least significant differences test (LSD) at 5% level of significance. Most of the studied parameters showed significant results ( $P \leq 0.05$ ) for yield and weed indices. The results showed that highest weed control efficiency (41.86%) was recorded for hand weeding followed by Ally Max (30.8%) which were significantly different from each other; while, in case of sowing methods, weed control efficiency was maximum (24.08%) for ridge sowing method. Similarly, grain yield was maximum (3.09 t ha<sup>-1</sup>) under the plot where hand weeding was performed followed by the plot where Ally max (2.68 t ha<sup>-1</sup>) was applied; whereas, highest yield was (2.84 t ha<sup>-1</sup>) obtained from line sowing method. So, it is concluded and recommended that for controlling broadleaved weeds hand weeding otherwise Ally Max herbicide through line sowing method results in a good yield of rain fed wheat.

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## Introduction

Wheat (*Triticum aestivum* L.) is the staple food of Pakistan and it ranked 1<sup>st</sup> among crops. It is an important cereal crop of Pothwar Region of Paki-

stan. It contributes about 10% to the agriculture and 2.1% to total GDP of the Country (ESP, 2014-2015). Average grain yield of wheat is 2.845 t ha<sup>-1</sup> which is very low (ESP, 2016-2017). The main reasons of this low yield of wheat in Pakistan are uncertainty of rain-

fall, lack of water, substandard methods of cultivation, malnutrition and weed invasion which may decrease up to 25-30 percent of yield (Nayyar et al., 1992). Farming in the pothowar rainfed tract is the relatively complex farming system. The complication arises due to the farm's small sizes combined with management approaches that depict several objectives of the farming community. The effect of the existing farming system perished the crop yield and failed to reduce undesirable weeds. To get maximum wheat yield is a major challenge. Many researchers tried their best to improve crop yield by using different methodologies and investigated their positive and negative effects on yield.

Weeds have strong competition with the wheat crop for light, nutrients, and moisture which adversely affect the wheat production. Therefore, a constant effort is needed to keep the weed population under control. Many methods of weed control and eradication are in practice, but chemical control is the most effective (Marwat et al., 2013). Many scientists worked out to check the response of different sowing methods on wheat yield. Hassan et al. (2003) observed that Fakhr-e-Sarhad, a wheat variety, showed the best performance when sown using line sowing method followed by the line + broadcast sowing. 2,4-D + Puma Super 75 EW, Buctril-M + Topik 15 WP and Topik 15 WP were at the top scoring applications which caused an increase in the wheat yield to the extent of 104, 107 and 101 %, respectively over the weedy check. Kristensen et al. (2008) reported that increased crop density had a positive effect on crop yield while the strong negative effect on weed population. At highest crop density weed population was less than half that at lowest density. Maximum seed yield of wheat can be obtained through line sowing method with the row spacing of 22.5cm (Abbas et al., 2009).

Strategies for sowing can essentially impact the weeds development in wheat. Dry matter yield of perennial grasses was higher in the row-sown plots than those sown by broadcasting method while mean dry matter yield of perennial grasses was lowest at the low sowing rate. But it is not significantly different at medium and high sowing rate (Lodge, 2000). Sowing methods inhibit the growth of weeds in different means containing canopy architecture, good stand, early germination, etc. Crop growth is mainly dependent on the ability of the canopy to capture incoming radiation under field conditions, which is a function of canopy architecture, and leaf area index (LAI) and then con-

vert it into new biomass (Gifford et al., 1984). Among the broadcast, line sowing and line + Broadcast sowing methods, line sowing proved to be best for weed management in wheat (Ashrafi, 2009). There is a need to check their competitive weed ability of newly developed wheat cultivars for field assessment as a significant research field (Hussain et al., 2000). The competitive ability of a crop plant can be used as a criterion to check the ability to prosper and thrive best under harsh weedy conditions (Mahajan and Chauhan, 2011). Type of tillage and weeds infestation reduces the wheat yield by 50-80% (Chhokar and Malik, 2002).

So, the present study was therefore, planned with the following main objectives:

- To find out the highly productive sowing technique of rainfed wheat for Pothwar Region.
- To search out the efficient herbicide for controlling the broad leaved weeds of rainfed wheat.

## Materials and Methods

### Study location

The study was carried out at University Research Farm, Chakwal Road Rawalpindi, located at latitude 32.9303° N, and longitude 72.8556° E and has an altitude of 2,500 feet (760 m) from sea level during Rabi season of 2015-2016. The physico-chemical analysis of the experimental soil is mentioned in Table 1.

**Table 1: Physico-Chemical Properties of Experimental Site.**

| Soil Characteristics                        | Soil Depths (cm) |       |       |
|---------------------------------------------|------------------|-------|-------|
|                                             | 0-15             | 15-30 | 30-45 |
| Ph                                          | 7.2              | 7.24  | 7.49  |
| Electrical Conductivity                     | 0.7              | 0.83  | 0.89  |
| Total Nitrogen (mgkg <sup>-1</sup> )        | 322              | 293   | 250   |
| Available Phosphorus (mgkg <sup>-1</sup> )  | 4.66             | 3.5   | 3     |
| Extractable Potassium (mgkg <sup>-1</sup> ) | 98               | 110   | 105   |

### Experimental design and treatments

The experimental design was RCBD with split plot arrangement. The gross plot size was 29 × 60m, whereas main plot size was 15 × 9m and subplot size was 2 × 9m. The experiment was laid out in split plot design with three replications. Sowing techniques were kept in the main plots and herbicides were applied in subplots. Replications were separated by a distance of 1m and treatments were separated by making bunds of 0.5m. Four types of sowing methods were used as Broadcasting, Line sowing, Ridge

sowing and Bed sowing while four types of herbicides were applied as Ally max (Metsulfuron-methyl 14.3% w/w + Tribenuron-methyl 14.3% w/w), Clean Wave (Aminopyralid 1% + Fluroxypyr 14% w/w), Starane M. (Fluroxypyr 10% + MCPA 40% w/w) and Buctril super (Bromoxinil 30% + MCPA 30% w/v) along with Control and Hand weeded plots.

### Seedbed preparation and sowing

Seed bed was prepared separately for each sowing method as per following; Broadcast method ( $S_1$ ) was used according to the farmers' practice i.e. this method was involved once deep ploughing with mould board plough at the start of moon soon followed by a shallow cultivation with cultivator followed by planker after each heavy rainfall till final seedbed preparation with two cultivations followed by planker resulting into a total of 8 cultivations followed by planker. The seed was sown through manual broadcasting before final cultivation. While in second sowing method ( $S_2$ ), i.e. line sowing, drill sowing was done after final seedbed prepared just like seedbed of broadcasting method in which seed, and fertilizer was placed in drill machine, and direct seeding of wheat was done with seed-cum fertilizer drill in lines. Fertilizer was banded at the time of wheat sowing with the seed-cum fertilizer drill to place fertilizer 5-7cm deep and away from each crop row. Each plot consisted of 09 rows and row to row distance was kept 22.5cm in line sowing method. In third sowing method ( $S_3$ ), i.e. ridge sowing method, the fallow cultivation was performed traditionally, and for sowing, the seed was broadcasted on prepared seedbed, and the ridges were made mechanically through tractor driven ridger. In ridge sowing 45cm row to row distance was maintained. For fourth sowing method ( $S_4$ ) called bed sowing, the fallow cultivation was performed traditionally, and sowing was done through bed planter on prepared seedbed where the seed was filled in the bin of bed planter and sowing and bed formation was carried out in one run of the tractor through bed planter. In bed sowing the width of beds was 66.5cm, and the width of furrow was 22.5 cm.

### Seed rate and cultivar used

The seed rate was 120 kg ha<sup>-1</sup>. The wheat cultivar (AUR 0809) was used as test cultivar. The wheat seed was collected from Prof. Dr. Kausar Nawaz Shah, Chairman Department of Plant Breeding and Genetics, Faculty of Crop and Food Sciences, Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi.

### Fertilization

Recommended dose of phosphorus and potassium was mixed into the soil at the time of sowing at the rate of 60:60 kg ha<sup>-1</sup>, respectively. Nitrogen was added at the rate of 90 kg ha<sup>-1</sup> in two splits. Half of the nitrogen was added at the time of sowing and remaining half dose was applied at the time of tillering stage as per availability of rainfall. Phosphorus was added in the form of DAP, Potash as SOP and Nitrogen in the form of Urea.

### Herbicide application

All herbicides were applied at the appearance of the first flush of weeds (after 45 days of sowing) in wheat at recommended doses with hand knapsack sprayer. All other agronomic and cultural practices were conceded as per recommendations.

### Weather data collection

Weather data was recorded during the period of study from nearby weather station (University Research Farm Meteorological Station) of experimental location to correlate it with the results. The weather data of the study area is depicted in Figure 1.

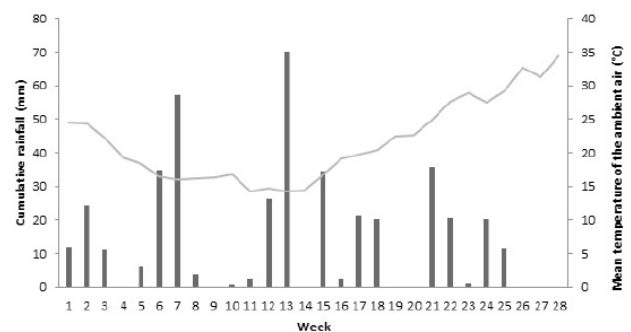


Figure 1: Temperature and Rainfall Data during Experimental Period.

### Data collection on weed and wheat indices

Data regarding grain yield of wheat, weed index of wheat, weeds mortality and weeds control efficiency was recorded using standard protocols as per following

### Grain yield (kg ha<sup>-1</sup>)

Each harvested sample of 1 m<sup>2</sup> was threshed manually after sun-drying. Grain yield m<sup>-2</sup> was recorded with the help of digital balance and it was converted to t ha<sup>-1</sup>.

### Weed index (WI)

Weed index was calculated using formula proposed by Gupta (1998):

$$WI = \frac{YHw - Yt}{YHw}$$



Where; YHw = Average yield of wheat in hand weeded, weed-free plot; Yt = Average yield of wheat in the plot under other weed control treatment.

### Weed mortality percentage

Half meter quadrat was used to determine the surviving weeds by taking two random samples from each plot before and after 20 days of treatment. Then mortality percentage was calculated for each treatment using the formula.

$$\text{Mortality\%} = \frac{W_t - W_s}{W_t} \times 100$$

Where;  $W_t$  = Total number of weeds before spray;  $W_s$  = Number of surviving weeds after spray.

### Weed control efficiency (WCE)

The weeds in the above quadrates were cut from ground surface level manually after application of treatments. The samples were dried in an oven at 65°C till constant weight. It was expressed as dry biomass  $m^{-2}$ . Weed dry biomass after spray was further used to calculate weed control efficiency. Weed control efficiency was calculated using the formula proposed by Gupta (1998):

$$\text{WCE} = \frac{W_c - W_t}{W_c} \times 100$$

Where;  $W_c$  = Average dry weed biomass  $m^{-2}$  in the un-weeded control plot after spray;  $W_t$  = Average dry weed biomass  $m^{-2}$  in the plot under treatment after spray.

### Statistical analysis

The data for all parameters under study were subjected to Fishers Analysis of Variance (ANOVA). Least Significant Difference (LSD) test was used for comparison among the treatment means using STATISTIX 8.1 software package (Steel et al., 1997).

## Results and Discussion

### Mortality rate (%) of weeds as affected by different herbicides and sowing methods of wheat

Mortality rate, or death rate, is a measure of the number of deaths (in general, or due to a specific cause) in a population, scaled to the size of that population, per unit of time. The mortality rate of weeds calculated on the base of reduction of number of weeds per unit area due to herbicides. All the herbicides showed significant ( $P \leq 0.05$ ) results for mortality rate as shown in (Figure 2). The maximum weeds mor-

tality rate (61.59 %) was noted under the plot where hand weeding was done followed by 58.86 %, 55.87 % and 55.34 % where Clean Wave, Buctril Super, and Ally Max was applied respectively and were statistically at par with each other; Whereas, lowest weeds mortality rate (-6.85 %) was obtained from the plot where no herbicide treatment was applied. In case of the mortality rate of weeds affected by different sowing methods, the highest weeds mortality rate (52.48 %) was obtained from bed sowing method followed by line sowing (49.03 %), broadcasting (44.04 %) and ridge sowing (38.82 %) method but statistically, they were similar. Lowest weeds mortality rate (38.82 %) was achieved in the plot where ridge sowing was used (Figure 3). As for as the comparison of herbicides and different sowing methods were concerned it showed significant results ( $P \leq 0.05$ ; Table 2), the maximum weeds mortality rate (83.04 %) was found in the plot where hand weeding was applied under bed sowing method which was statistically different from other herbicides. Minimum weeds mortality rate (-8.18 %) was found in a plot where no herbicide was applied in line sowing method followed by -6.72 %, -6.53 % and -5.98 % in control plots of bed sowing, broadcasting and ridge sowing method which were statistically at par with each other but different from other herbicidal treatments. The maximum weeds mortality rate (83.04 %) achieved under hand weeding in bed sowing may be due to the focused and precisely direct control of weeds through hand weeding in large amount under this treatment, and ultimately the crop plants may have got maximum nutrient for their growth. The lowest weeds mortality rate (-8.18 %) found from control plots may be due to a large amount of weeds in control plot and ultimately a hard competition between crop plant and weeds for nutrients, minerals moisture and water, etc. may have affected the yield of wheat crop adversely (Asad et al., 2017).

**Table 2:** Mortality rate (%) of weeds as affected by different herbicides and sowing methods of wheat.

| Herbicides    | Sowing Methods |             |            |              |
|---------------|----------------|-------------|------------|--------------|
|               | Broad casting  | Line sowing | Bed Sowing | Ridge Sowing |
| Ally Max      | 54.80 bcd      | 64.14 bc    | 62.23 bc   | 41.78 d      |
| Clean Wave    | 61.09 bc       | 56.61 bcd   | 64.90 bc   | 52.83 cd     |
| Starane M     | 48.72 cd       | 59.01 bcd   | 54.66 bcd  | 42.97 d      |
| Buctril Super | 55.85 bcd      | 51.49 cd    | 56.79 bcd  | 59.34 bc     |
| Hand Weeded   | 50.33 cd       | 71.08 ab    | 83.04 a    | 41.95 d      |
| Control       | -6.53 e        | -8.18 e     | -6.72 e    | -5.98 e      |

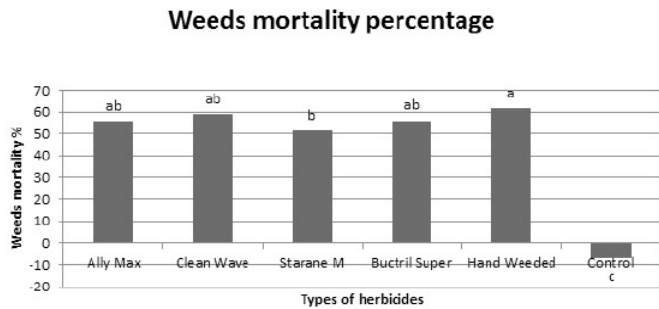


Figure 2: Weeds mortality percentage under different herbicides.

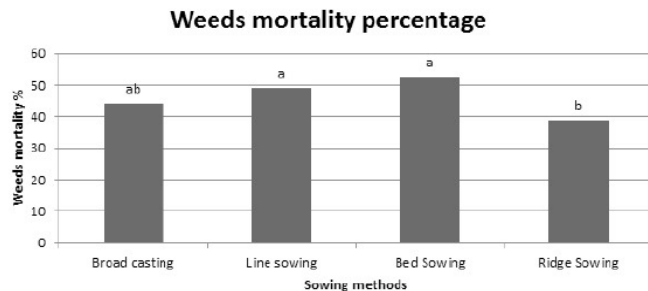


Figure 3: Weeds mortality percentage under different sowing methods of wheat.

#### Weed control efficiency (%) of herbicides and sowing methods of wheat

Weed control efficiency calculated on the basis of reduction of dry biomass of weeds per unit area due to herbicides. Effect of different herbicides on weed control efficiency was found significant ( $P \leq 0.05$ ). The Figure 4 showed that among the weed management practices the highest weed control efficacy (41.86 %) was recorded where hand weeding was practiced followed by Ally Max (30.88 %), Buctril Super (25.67 %) and Clean Wave (19.36 %). While the lowest weed control efficiency (0.00 %) was recorded in control treatment and all were significantly different from each other. Similarly, the effect of different sowing methods on weed control efficiency was significant (Figure 5); where the highest weed control efficacy (24.08%) was recorded in ridge sowing method followed by bed sowing method (21.77 %) and line sowing method (20.31 %); however, the lowest weed control efficiency (19.34 %) was observed in the broadcast method. The interaction of different herbicides and sowing methods showed non-significant results ( $P \geq 0.05$ ; Table 3). Maximum weed control efficiency (50.54 %) was found in the hand weeding plot in line sowing method followed by bed sowing (42.08 %), ridge sowing (39.42 %) and broadcast sowing (35.39 %). The minimum weed control efficacy (0.00 %) was found from the plot where no herbicide was applied. The maximum weed control efficiency was observed under Ally max herbicide ap-

plied plots where crop plants got maximum nutrient for their growth. The lowest weed control efficiency was found from control plots due to a large amount of weed and hard competition between crop plant and weeds for nutrients, minerals moisture and water, etc. which ultimately affected the wheat crop yield negatively. Interestingly hand weeding was better than Ally Max and Buctril Super application that might be due to direct and focused hand weeding. Present findings are in accordance with Pandey et al. (2001) and Asad et al. (2017), who reported that herbicides and different sowing methods provide better weed control than the control treatment.

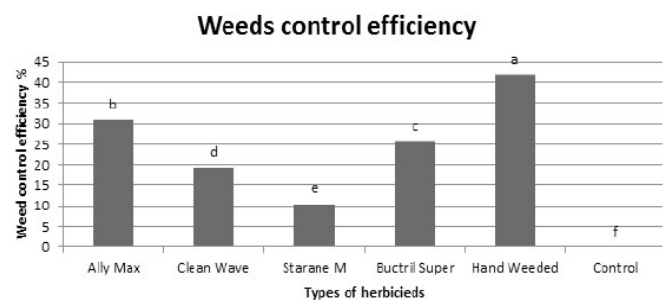


Figure 4: Weed control efficiency of different herbicides in wheat.

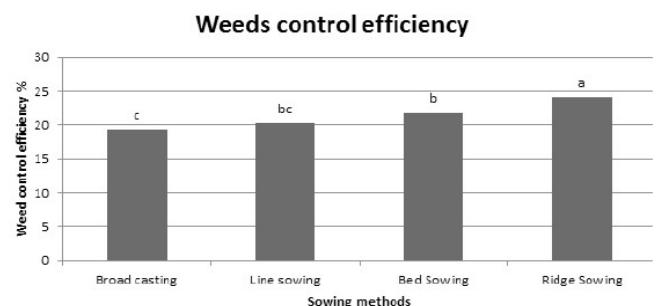


Figure 5: Weed control efficiency of different sowing methods of wheat.

Table 3: Weed control efficiency (%) of different herbicides and sowing methods of wheat.

| Herbicides    | Sowing Methods |             |            |              |
|---------------|----------------|-------------|------------|--------------|
|               | Broad casting  | Line sowing | Bed Sowing | Ridge Sowing |
| Ally Max      | 29.78          | 30.57       | 28.70      | 34.47        |
| Clean Wave    | 17.85          | 18.66       | 18.18      | 22.76        |
| Starane M     | 8.03           | 7.48        | 8.57       | 17.81        |
| Buctril Super | 24.98          | 23.35       | 24.34      | 30.03        |
| Hand Weeded   | 35.39          | 50.54       | 42.08      | 39.42        |
| Control       | 0.00           | 0.00        | 0.00       | 0.00         |

#### Grain yield ( $t\ ha^{-1}$ ) of wheat as affected by different herbicides and sowing methods

Grain yield is an important factor as it is of main concern for farmers. Different weed control treatments

depicted a positive influence on wheat grain yield. All the herbicides showed significant ( $P \leq 0.05$ ) results for grain yield (Figure 6). The maximum grain yield ( $3.09 \text{ t ha}^{-1}$ ) was noted under the plot where hand weeding was conducted followed by  $2.68 \text{ t ha}^{-1}$ ,  $2.46 \text{ t ha}^{-1}$  and  $2.28 \text{ t ha}^{-1}$  where Ally max, Buctril super and Clean Wave were applied, respectively; Whereas, lowest grain yield ( $1.83 \text{ t ha}^{-1}$ ) was obtained from the plot where, no weed control treatment was applied. In case of grain yield of wheat affected by different sowing methods, highest grain yield ( $2.84 \text{ t ha}^{-1}$ ) was obtained from line sowing method as compared to bed sowing method ( $2.53 \text{ t ha}^{-1}$ ) and broad casting ( $2.24 \text{ t ha}^{-1}$ ). The lowest grain yield ( $2.03 \text{ t ha}^{-1}$ ) was achieved in the ridge sowing method plot (Figure 7). The maximum grain yield was obtained where minimum weed crop competition for nutrients and water was existed. As for as the interaction of herbicides and different sowing methods is concerned it showed significant results ( $P \leq 0.05$ ; Table-4), maximum grain yield ( $3.88 \text{ t ha}^{-1}$ ) was found in the hand weeding plot where line sowing method was done followed by  $3.18 \text{ t ha}^{-1}$ ,  $2.79 \text{ t ha}^{-1}$ , and  $2.49 \text{ t ha}^{-1}$  in hand weeding plot of bed sowing, hand weeding plot of broad casting method and hand weeding plot of ridge sowing method which were statistically different from other herbicidal treatments. Minimum grain yield ( $1.52 \text{ t ha}^{-1}$ ) was found from the plot where no any weed control treatment was applied. Maximum grain yield was achieved where weeds were suppressed in large amount and plants may have got sufficient nutrients for their growth. The lowest grain yield was found from control plots that may be due to large number of weeds and hard competition between crop plants and weeds for nutrients, minerals, moisture and water, etc. which ultimately affected the grain yield of wheat. Similar findings were reported by Ahmad et al. (1993), Singh and Singh (1996) and Subhan et al. (2003) who concluded that herbicide application and hand weeding increased grain yield of wheat as compared to weedy check. Shafi et al. (2004) also confirmed these findings who reported that maximum grain yield was produced by the plots which were treated with herbicides at tillering stage while minimum in weedy plots.

#### Weed index as affected by different herbicides and sowing methods of wheat

Weed index is the percent loss of yield of a crop due to weeds. Different weed control treatments depicted a significant influence on weed index. All herbicides

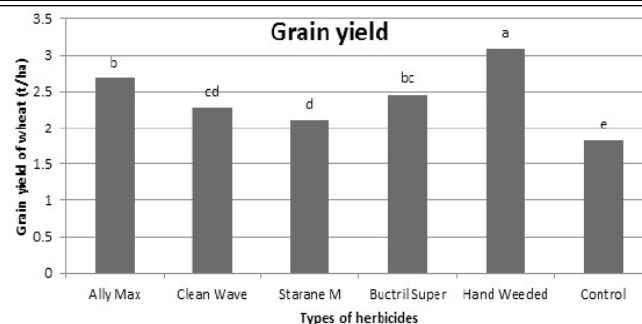


Figure 6: Grain yield of wheat ( $\text{t/ha}^{-1}$ ) as affected by different herbicides.

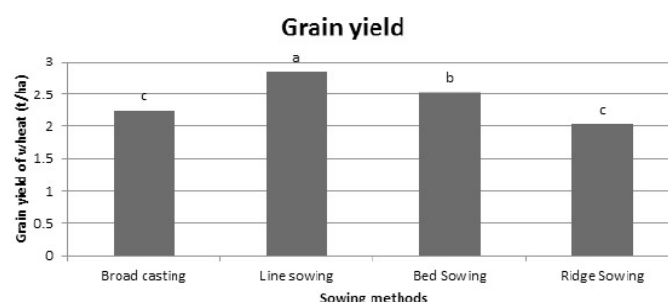


Figure 7: Grain yield of wheat ( $\text{t/ha}^{-1}$ ) as affected by different sowing methods.

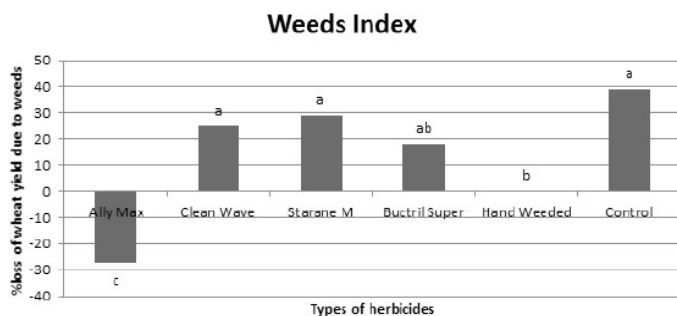
Table 4: Grain yield ( $\text{t ha}^{-1}$ ) of wheat as affected by different herbicides and sowing methods.

| Herbicides    | Sowing Methods |             |            |              |
|---------------|----------------|-------------|------------|--------------|
|               | Broad casting  | Line sowing | Bed Sowing | Ridge Sowing |
| Ally Max      | 2.55 defg      | 3.07 bc     | 2.87 bcd   | 2.23 ghij    |
| Clean Wave    | 2.06 ghijk     | 2.74 bcdef  | 2.36 efghi | 1.94 ijkl    |
| Starane M     | 2.03 hijk      | 2.39 defghi | 2.23 ghij  | 1.79 jkl     |
| Buctril Super | 2.29 fghij     | 2.81 bcde   | 2.57 cdefg | 2.18 ghijk   |
| Hand Weeded   | 2.79 bcdef     | 3.88 a      | 3.18 b     | 2.49 defgh   |
| Control       | 1.70 kl        | 2.13 ghijk  | 1.98 ijkl  | 1.52 l       |

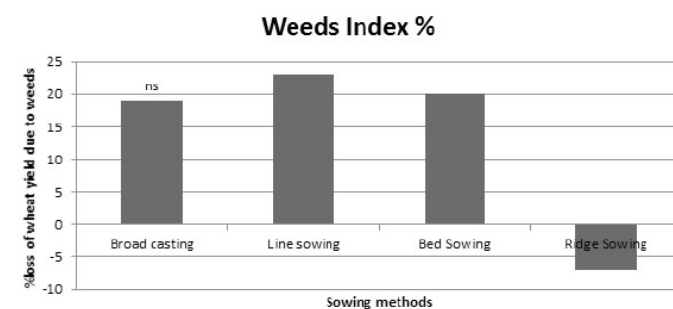
showed significant ( $P \leq 0.05$ ) results on weed index showed in (Figure 8). The maximum yield loss/weed index (39 %) was noted under the control plot (weedy check) followed by 29 %, 26% and 18 % where Starane M, Clean Wave and Buctril Super was applied respectively. Whereas, lowest yield loss/weed index (-27%) was obtained from the plot where, Ally max was applied. It means that yield was improved up to 27 % where Ally max was sprayed that may be due to its unique characteristic or there may be any kind of growth promoter in this chemical. This observation agrees with works of Patel et al. (2003), who reported that different herbicides significantly affected the weed index of wheat. While in case of weed index of wheat as affected by different sowing methods, it showed non-significant results (Figure 9), the high-



est weed index (23%) was obtained from line sowing method as compared to bed sowing method (20 %), broad casting method (19 %) and ridge sowing method (-7 %). As for as the interaction of different herbicides and sowing methods is concerned it showed significant results ( $P \leq 0.05$ ; Table 5), maximum weed index/loss in wheat yield due to weeds was (42 %) found in the plot where no herbicide and ridge sowing method was applied followed by 39 %, 38 % and 38 % in control plot of broad casting, control plot of ridge sowing and control plot of bed sowing method which were statistically different from other herbicides effect. The minimum loss of yield due to weeds/weed index (-141 %) was observed in plot where Ally max was applied under ridge sowing method. The minimum weed index achieved under Ally max herbicide supports that this herbicide may have some kind of growth hormone which increased the growth of wheat crop and resulted in the higher yield of wheat. The highest weed index found in control plots may be due to large amount of weeds and hard competition between crop plants and weeds for nutrients, minerals, moisture and water, etc. which ultimately affected the weed index. This observation agrees with the report of Dadari (2003) and Asad et al. (2017), who stated that competition between weeds and crop starts right from germination of the crop up to harvest affecting both growth and yield parameters adversely.



**Figure 8:** Percent loss in yield of wheat due to weeds/weeds index under different herbicides.



**Figure 9:** Percent loss in yield of wheat due to weeds/weeds index under different sowing methods of wheat.

**Table 5:** Weed index as affected by different herbicides and sowing methods of wheat.

| Herbicides    | Sowing Methods |             |             |              |
|---------------|----------------|-------------|-------------|--------------|
|               | Broad casting  | Line sowing | Bed Sow-ing | Ridge Sowing |
| Ally Max      | 8.5 a          | 16 a        | 9 a         | (-)141 b     |
| Clean Wave    | 26 a           | 25 a        | 26 a        | 22 a         |
| Starane M     | 27 a           | 34 a        | 29 a        | 28 a         |
| Buctril Super | 18 a           | 23 a        | 19 a        | 13 a         |
| Hand Weeded   | 0 a            | 0 a         | 0 a         | 0 a          |
| Control       | 39 a           | 42 a        | 38 a        | 38 a         |

## Conclusions and Recommendations

It is concluded that hand weeding followed by Ally Max herbicide showed best results among all herbicide treatments, while in case of sowing techniques line sowing resulted in good yield as compared to other sowing techniques. So hand weeding followed by Ally max with line sowing is recommended to the farmers of this region.

## Acknowledgments

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## Author's Contribution

Abid Muhammad Shah and Gulzada Wazir conducted the field experiment and Safdar Ali, Ijaz Ahmad, Bashir Ahmad Khan and Sumaira Zareen provided technical input throughout the experiment; whereas, Obaidullah Shafique and Muhammad Amir Hanif helped in writing the article.

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