Effect of Differential Responses of Weed Infestation on Shoot Functional Traits of Wheat (*Triticum aestivum* L.)

Amandeep Kaur, Rajni Yadav, Anand Narain Singh

**ABSTRACT**

**Background:** Shoot functional traits that help the plant to increase its competitive ability, mechanical strength and allocation of photosynthetic products and nutrients from soils in shoot formation strengthens the plant growth. To understand the complexity of weed-crop competition via plant functional traits might be a feasible option and that can provide a better understanding of weed ecology.

**Methods:** Present study was designed to understand the performance of wheat crop under weed infestation (*Avena* and *Phalaris* combination) during each rabi season of 2014-2017 at the experimental enclosure of Panjab University, Chandigarh. This experiment was established with water and fertilizer treatments following the Latin Square Matrix (LSM) model.

**Result:** Results indicated that under a different mixed combination of weeds, growth parameters of wheat crop such as shoot functional traits were significantly distinguishable. However, the maximum differential response in corresponding parameters was found under combination when the wheat was grown in mixed with both the weeds and when full doses of fertilizers and water were applied. This finding now confirms that these weeds have much more inclination to exploit available resources and provide a high degree of interspecific competition to the wheat crop.

**Key words:** *Avena*, *Phalaris*, Shoot traits, Wheat, Weeds.

**INTRODUCTION**

Wheat is an important cereal crop in India; however, its productivity is lower as compared to other wheat-growing countries of the world (Ramadas et al., 2019). Wheat (*Triticum* sp.) is the most widely cultivated crop of the world and it is the staple food of about nearly 40% world population. In India, nearly 18 species of *Triticum* are being cultivated; whereas, more than 90 species of weeds infest this crop in the Indian sub-continent (Pandey et al., 1997). The effects of weed competition on crop plants presumably depend on the capability of growth factors, along with this, many agronomic characteristics such as crop density, sowing date, varieties and fertilizers timing and application methods can enhance the competitive crop ability against weeds (Sonderskov et al., 2012, Khatik et al., 2020). To understand mechanism of weed-crop interaction, plant functional traits is a feasible option and can provide a better understanding of weed ecology.

Important growth traits (i.e. shoot traits), that help the plant to increase its competitive ability and mechanical strength. On the other hand, the allocation of photosynthetic products and nutrients from soils in shoot formation strengthens the plant growth. Many studies showed the control of shoot traits and tillering in enhancing plant growth and crop yield (Tavakol et al., 2015).

Therefore, present study was conducted to assess the ability of weeds (*Avena sativa* L. and *Phalaris minor* Retz.) by using selected plant functional traits mainly shoot traits of the wheat crop which raised under various combinations and treatments intending to explore the complexity of weed-crop competition via plant functional traits particularly shoot traits.

**MATERIALS AND METHODS**

The field experiment was conducted during the rabi season of 2014-2015, 2015-2016 and 2016-2017 at Panjab University, Chandigarh, India. The investigation was conducted in Latin square matrix design with three replications. The climate of the experimental area is humid subtropical. The maximum temperature during this season ranged 16°C - 25°C, while the minimum temperature ranged 9°C-18°C. The average annual rainfall is about 1100 mm. The experimental soil was sandy loam in texture with pH 7.7. The treatment comprised of four crop establishment methods viz (1) monoculture (W) (100% of *Triticum aestivum* L.) (2) mixed-culture plots (W+A)
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(50:50%) seeds of wheat and *Avena* (3) mixed culture as (W+P) (50:50%) seeds of wheat and *Phalaris* and (4) wheat with both *Avena* and *Phalaris* (W+A+P) (33:33:33%) and 5 levels of NPK and water treatment (2 Levels each of NPK and water treatment including control).

The data on growth plant height, shoot length, the number of tillers, shoot weight ratio were recorded manually on five selected randomly selected representative plants from each plot of each replication separately as per the standard method. The data obtained from various characters under study were analyzed by analysis of variance given by SPSS-PC statistical software (version-14).

**RESULTS AND DISCUSSION**

Effect of crop weed competition on growth parameters of wheat crop

**Plant height**

Significantly highest plant height was recorded in monoculture among the crop establishment methods while lowest was recorded in wheat sown with *Avena* and *Phalaris* (Table 1). This might have happened due to weeds are growing vigorously and has more ability to achieve greater height, develop wide leaf area and horizontal branches when moisture and nutrients are not limiting which allow them to shade and suppress the growth of the

| Combinations | DAS (days) | Average | CD (p=0.05) |
|--------------|------------|---------|--------------|
| W            |            |         |              |
| A            |            |         |              |
| P            |            |         |              |
| W(W+A)       |            |         |              |
| A(W+A)       |            |         |              |
| W(W+P)       |            |         |              |
| A(W+P)       |            |         |              |
| P(W+P)       |            |         |              |

| Table 1: Effect of wheat crop sown with associated weeds on plant height (cm) (pooled data of three years). |

**Shoot length**

The data on shoot length were recorded manually on five selected randomly selected representative plants from each plot of each replication separately as per the standard method. The data obtained from various characters under study were analyzed by analysis of variance given by SPSS-PC statistical software (version-14).

| Combinations | DAS (days) | Average | CD (p=0.05) |
|--------------|------------|---------|--------------|
| W            |            |         |              |
| A            |            |         |              |
| P            |            |         |              |
| W(W+A)       |            |         |              |
| A(W+A)       |            |         |              |
| W(W+P)       |            |         |              |
| A(W+P)       |            |         |              |
| P(W+P)       |            |         |              |

| Table 2: Effect of wheat crop sown with associated weeds on shoot length (cm) (pooled data of three years). |

**Number of tillers**

The data on number of tillers were recorded manually on five selected randomly selected representative plants from each plot of each replication separately as per the standard method. The data obtained from various characters under study were analyzed by analysis of variance given by SPSS-PC statistical software (version-14).

| Combinations | DAS (days) | Average | CD (p=0.05) |
|--------------|------------|---------|--------------|
| W            |            |         |              |
| A            |            |         |              |
| P            |            |         |              |
| W(W+A)       |            |         |              |
| A(W+A)       |            |         |              |
| W(W+P)       |            |         |              |
| A(W+P)       |            |         |              |
| P(W+P)       |            |         |              |

| Table 3: Effect of wheat crop sown with associated weeds on number of tillers (pooled data of three years). |
main crop to a last level of yield reduction. These results were in collaboration with the findings of Khan et al. (2007) and Sinha et al. (2009).

**Shoot length**

Shoot length is one of the important functional traits which express morphological growth of the plant. Significantly highest shoot length was recorded in monoculture which might have happened due to the fact that shoot length of wheat undergoes significant reduction under mixed-culture combination with *Phalaris minor* and *Avena sativa* (Table 2). Further, it was also observed that weed had the more competitive ability and has comparatively better growth efficiency in shoot height than the crop. This might be due to the similarity between physiological and morphological traits of wheat and the weeds which resulted in similar capacity to utilize the natural resources. Similar findings were also reported by Sinha et al. (2009) and Singh et al. (2017).

**Number of tillers**

Number of tillers reflects the establishment of crop, canopy structure and also the yield to be obtained from the crop, so these are the direct indicators of vegetative growth progress of crops. Significantly highest number of tillers were recorded in wheat crop sown in association with *Phalaris minor* and *Avena sativa* indicating high degree of suppression up to 22.34% is provided by the weeds (Table 3). The findings of the present experiment are in accordance with there of Pisal and Sagarka, (2013) which specified that number of tillers of wheat crop undergo reduction in wheat-weed mixture plots than monoculture and it was also observed that *Avena fatua* was found to be more dominating than *Phalaris minor* in effective tillers of wheat crop.

**Shoot weight ratio**

Wheat crop sown with associated weeds on shoot weight ratio varies significantly. However, the significantly lowest difference was observed between monoculture and crop sown with associated weeds (Table 4). This is probably due to more capacity to accumulate nutrient, more photo synthesis and more dry matter uptake by weeds from the soil which provided more competitive regimes to that in turn struggling for nutrient utilization by wheat crop.

### Table 4: Effect of wheat crop sown with associated weeds on shoot weight ratio (pooled data of three years).

| Combinations | DAS (days) | Average | CD (p=0.05) |
|--------------|------------|---------|-------------|
|              | 30-        | 60-     | 90-         | 120-       |         |
| W            | 0.944      | 0.916   | 0.944       | 0.987      | 0.948   | 0.06    |
| A            | 0.955      | 0.908   | 0.944       | 0.988      | 0.949   | 0.08    |
| P            | 0.779      | 0.782   | 0.925       | 0.988      | 0.869   | 0.21    |
| W(W+A)       | 0.950      | 0.915   | 0.922       | 0.974      | 0.940   | 0.06    |
| A(W+A)       | 0.960      | 0.888   | 0.942       | 0.982      | 0.943   | 0.08    |
| W(W+P)       | 0.938      | 0.837   | 0.907       | 0.972      | 0.913   | 0.16    |
| P(W+P)       | 0.809      | 0.899   | 0.931       | 0.988      | 0.907   | 0.19    |
| W(W+A+P)     | 0.945      | 0.944   | 0.960       | 0.970      | 0.955   | 0.04    |
| A(W+P)       | 0.944      | 0.888   | 0.927       | 0.989      | 0.937   | 0.43    |
| P(W+P)       | 0.974      | 0.921   | 0.916       | 0.947      | 0.940   | 0.08    |

### Table 5: Effect of nutrients and water on plant height of wheat crop (pooled data of three years).

| Treatments | DAS (days) | Average | CD (p=0.05) |
|------------|------------|---------|-------------|
|            | 30-        | 60-     | 90-         | 120-       |         |
| C          | 34.55      | 57.25   | 102.66      | 117.62     | 78.02   | 104.51  |
| FNPK       | 38.00      | 73.23   | 118.85      | 132.22     | 90.57   | 116.35  |
| HNPK       | 33.27      | 66.32   | 111.28      | 122.59     | 83.37   | 111.00  |
| FW         | 31.81      | 50.45   | 76.47       | 92.13      | 62.71   | 72.65   |
| HW         | 27.38      | 44.84   | 67.04       | 79.42      | 54.67   | 63.71   |

### Table 6: Effect of nutrients and water on shoot length of wheat crop (pooled data of three years).

| Treatments | DAS (days) | Average | CD (p=0.05) |
|------------|------------|---------|-------------|
|            | 30-        | 60-     | 90-         | 120-       |         |
| C          | 30.76      | 49.54   | 93.34       | 107.81     | 70.36   | 98.31   |
| FNPK       | 33.34      | 62.79   | 106.41      | 119.22     | 80.44   | 107.27  |
| HNPK       | 29.41      | 57.24   | 100.92      | 111.48     | 74.76   | 103.59  |
| FW         | 28.18      | 45.02   | 68.80       | 83.66      | 56.41   | 67.13   |
| HW         | 23.66      | 40.22   | 60.27       | 72.15      | 49.07   | 58.73   |
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**Effect of NPK and water Treatments**

**Plant height**

A perusal of data presented in Table 5 revealed that significantly highest plant height was observed with full dose of NPK which indicated that with an increase in doses of NPK increase the corresponding parameter and decreased in water deficit conditions. These results are in accordance with findings of Raghuwanshi et al. (2018). This might be because of the favourable environment of growth resulted in more cell division and cell elongation in the meristematic zone.

Table 7: Effect of nutrients and water on number of tillers of wheat crop (pooled data of three years).

| Treatments | 30- | 60- | 90- | 120- | Average | CD (p=0.05) |
|------------|-----|-----|-----|------|---------|-------------|
| C          | 1.21| 2.32| 3.89| 3.27 | 2.67    | 4.14        |
| FNPK       | 1.28| 3.70| 5.54| 4.62 | 3.79    | 6.00        |
| HNPK       | 1.22| 2.89| 4.84| 4.03 | 3.25    | 5.00        |
| FW         | 1.11| 1.38| 2.27| 2.06 | 1.70    | 2.32        |
| HW         | 1.04| 1.14| 1.87| 1.74 | 1.45    | 1.78        |

Table 8: Effect of nutrients and water on shoot weight ratio of wheat crop (pooled data of three years).

| Treatments | 30- | 60- | 90- | 120- | Average | CD (p=0.05) |
|------------|-----|-----|-----|------|---------|-------------|
| C          | 0.917| 0.899| 0.938| 0.983| 0.935  | 0.19        |
| FNPK       | 0.905| 0.919| 0.949| 0.987| 0.940  | 0.52        |
| HNPK       | 0.938| 0.892| 0.946| 0.988| 0.941  | 0.27        |
| FW         | 0.900| 0.860| 0.907| 0.969| 0.909  | 0.37        |
| HW         | 0.939| 0.879| 0.919| 0.965| 0.926  | 0.37        |

**Fig 1:** Interaction of combination and treatment effects on plant height (cm) of wheat crop and their associated weeds. Values are means of pooled data of three years.
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tissues of plants that leads to a significant increase in the plant height.

**Shoot length**

The data presented in Table 6 revealed that significantly highest shoot length was recorded with a full dose of NPK. This parameter increased with an external supply of the nutrient resources in the form of NPK fertilizers and water supply. These findings are inconsistent with Yadav and Dhani (2017).

**Number of tillers**

Significantly highest number of tillers were observed with a full dose of NPK (Table 7). This might have happened due to fact that with increasing rates of fertilizer application, particularly nitrogen, may be attributed to enrichment of protoplasm content of the plant and acceleration of metabolic processes results in the maximum number of tillers. This may be due to increased cell division and meristematic activity resulted from supply of nutrients in the form of fertilizers. Similar findings were also observed by Pandey et al. (2013).

**Shoot weight ratio**

Results showed that maximum shoot weight ratio was observed in HNPK followed by HNPK, control, HW and FW (Table 8). The same trend was reported by Mohil and Jain, (2016) in which they found that there was a gradual increase in shoot biomass with an increase in the concentration of NPK at different plant growth stages. This may be due to an increase in fertilization which leads to a change in the allocation of biomass to plant parts causing an increase in accumulation of biomass in shoots (Singh et al., 1991). On the other hand, it is seen that water treatments, HW has more

![Fig 2: Interaction of combination and treatment effects on shoot length (cm) of wheat crop and their associated weeds. Values are means of pooled data of three years.](image-url)
shoot weight ratio than FW but both have less shoot weight ratio than control. According to the findings of Shahi et al. (2015) in which they found that water stresses decreased the shoot biomass of wheat from control conditions, as less growth was seen under water deficit stress.

**Effect of Interaction (Combinations × Treatments) Plant height**

The variables (combinations and treatments) showed significant effect on this corresponding parameter of wheat crop and its weeds (Fig 1). Competition between weeds and wheat crop for resources, particularly for nutrients and water might not have been severe in the early stage.

**Shoot length**

Maximum shoot length of wheat, *Avena* and *Phalaris* was observed in monoculture in FNPK while minimum in W+A+P combination in HW which showed 75.11% reduction (Fig 2). The variables (combinations and treatments) showed a significant effect on the shoot length of wheat and its weeds *Avena* and *Phalaris* has more shoot length. These can be related with the findings of Bogale et al. (2011) in which they observed that light penetration was more pronounced in monoculture where more shoot growth than in wheat-*Avena* mixture suggesting competitiveness of weed in the utilizations of given nutrients and water resources.

**Number of tillers**

Maximum growth number of tillers of wheat, *Avena* and *Phalaris* has been observed in monoculture in FNPK whereas minimum number of tillers of wheat in W+P in HW (Fig 3). Productive tillers reduction due to weed competition was started at 45 DAS for nutrients uptake from soil when NPK fertilizers were applied.

**Shoot weight ratio**

The results revealed that significantly maximum shoot weight ratio of wheat in monoculture and of *Phalaris* observed in

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Fig 3: Interaction of combination and treatment effects on number of tillers (individual-1) of wheat crop and associated weeds. Values are means of pooled data of three years.
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*W+P* combination in FNPK treatment whereas of *Avena* in *W+A+P* combination in HNPK treatment while minimum of wheat in *W+P* in HNPK (Fig 4.). These findings are in line with those reported by Das and Yaduraju (1999) who also observed maximum dry weight in the weed free plots resulting in more accumulation of photosynthates and greater biomass under given fertilizers and water treatments.

**CONCLUSION**

The present study concludes that the plant height, along with other shoot functional traits of wheat crop suppressed due to interference of both weeds (*A. sativa* and *P. minor*) and difference observed due various doses of nutrient and water conditions. Both weeds simultaneously have more capacity to undertake the maximum nutrients and water resources at the growth stage of the wheat crop while grown together. Our results showed that these weeds have much more inclination to exploit available resources and provide high degree of inter-specific competition to the wheat crop.

**ACKNOWLEDGEMENT**

We are very thankful to the Chairperson, Department of Botany, Panjab University, Chandigarh for providing all the required facilities during research work. AK is gratefully acknowledged the University Grants Commission, Government of India, New Delhi for financial support in the form of RGNF fellowship (Rajiv Gandhi National Fellowship).

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