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# Determination of allelopathic effect of winter weeds on nutrient content and uptake in wheat

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**Abstract**
Environmental contamination, herbicide resistance development among weeds and health concerns due to over and misuse of synthetic herbicides has led the researchers to focus on alternative weed management strategies. Allelochemicals extracted from various plant species can act as natural weed inhibitors. In this study, allelopathic aqueous extracts from *Medicago denticulata, Chenopodium album* and *Melilotus indica* as sole and combined application were tested for their effect on nutrient content and uptake in wheat by inhibiting the most problematic weed of wheat, *Phalaris minor*. The nitrogen, phosphorus and potassium content in grain and straw of wheat as well as straw of *Phalaris minor* gave non-significant results under various treatments. However, the variation in nitrogen, phosphorus and potassium uptake differ significantly at harvest for grain and straw of wheat, straw of *Phalaris minor* as well as total except for total phosphorus uptake. Nitrogen, phosphorus and potassium uptake by grain and straw of wheat under control condition was lower than under other treatments, respectively. It clearly showed the loss of nutrients due to crop weed (*Phalaris minor*) competition and the efficiency of allelochemicals in controlling *Phalaris minor* compared to control conditions as nitrogen, phosphorus and potassium uptake by wheat was found higher under treatments in which control of *Phalaris minor* was better. This indicated that effective weed control reduced competition between crops and weeds which resulted in better utilization of available nutrients by the crop plant.

**Keywords:** *Medicago denticulata, Melilotus indica, Chenopodium album, Phalaris minor,* allelo-chemical, aqueous extract

## 1. Introduction

Wheat is a staple food of masses in India; grown almost in every corner of the country. Amongst the several factors hindering the productivity of wheat, weed infestation is one of the major constraints hampering the harvest of potential yield, causing 20-40% reduction in wheat yield (Ahmad and Shaikh, 2003) [2], which in monetary terms is Rs. 146 billion per annum (Razzaq *et al*., 2012) [10]. Among many weeds, littleseed canarygrass (*Phalaris minor* Retz.) is widespread in rice-wheat cropping system of India. Due to its strong competitive ability with wheat, it can cause 10-50% yield losses (Ranjit *et al*., 2006) [9]. This weed not only cause yield reduction but also deteriorate the produce quality by seed mixing with grains and interfere the harvest operations. Nutrient losses due to weeds in wheat are also very high as was studied by Abouzeina *et al.* (2008) [1] and Kumar and Agarwal (2010) [7] who observed that weeds compete very effectively with the crop for available nitrogen to the point that the reduction in yields from weed competition were generally accompanied by reduction in protein content as well. Kanaujia (2006) [5] showed that under competition with weeds, greater part of the nutrients was shared by weeds; therefore crop suffered from nutrient deficiencies and gave lower yields. Sharing of nutrients by weeds not only cause deficiency of nutrients for the main crop but also deteriorates the nutritional status of crop. Present agricultural system is productivity oriented and depends mainly on inorganic inputs (herbicides) to control pests (weeds) (Sadeghi *et al*., 2010) [11]. Isoproturon was recommended for the control of *Phalaris minor* in wheat. But extensive use of isoproturon over many years has led to the evolution of resistance in *Phalaris minor* in northwest India (Chhokar and Malik, 2002) [3]. Therefore, continued reliance on isoproturon after the development of resistance resulted in a heavy buildup of *Phalaris minor* populations, as competition from other weeds was removed. This caused heavy yield losses in wheat. The main reason for winter wheat cultivars varied tolerance to herbicide is because of diverse viability to plant metabolic and morphological properties that govern herbicide uptake and translocation. This led to adoption of fenoxaprop, clodinafop, and sulfosulfuron in isoproturon resistant areas since 1997 that initially gave higher yields, but resulted in a weed flora shift and resistance problems at few places, which eventually reduced yields and increased the cost of weed management.

Environmental damages (Zhu and Li 2002) [13] and health concerns due to over and misuse of synthetic herbicides (Kudsk and Streibig 2003) [6] were the other problems associated with misuse of chemical herbicides that led the researchers to focus on alternative weed management strategies. Allelopathy offers an innovative and attractive option for organic farming (Yongqing, 2005) [12] and may be employed for weed management as well (Farooq *et al*., 2011) [4]. Plants posses various naturally occurring chemicals (allelochemicals) in the form of secondary metabolites which may leach out from their various parts to the surrounding rhizosphere either as exudates or rain-residues that may directly or indirectly influence germination, growth and other developmental processes of nearby plants. In this connection, allelopathic plants may widely be used in sustainable agriculture for their potential role in herb/weed and insect/pest management. Studies specifically exploring the management of *Phalaris minor* by using medicinal/allelopathic plants are very few (Om *et al*., 2002) [8]. However, the three major broad leaved weeds of wheat- *Medicago denticulata*, *Melilotus indica* and *Chenopodium album* are known to release certain allelochemicals like phenolic compounds, flavonoids, terpenoids, alkaloids, steroids, carbohydrates, and amino acids etc. from their roots, stems, leaves and decomposition products that inhibit the germination and growth of number of crop plants and weed species. This study was undertaken with the objectives of evaluating the allelopathic effect of aqueous extracts of *Medicago denticulata*, *Melilotus indica* and *Chenopodium album* at 10% concentration as sole and combined pre emergence application on Nitrogen, Phosphorus and Potassium content and uptake in wheat crop by controlling the growth of little canary grass (*Phalaris minor* Retz.).

## Materials and Methods

### Collection of donor plant material

The fresh biomass of required weeds was collected from the Norman E. Borlaug Crop Research Centre, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar during *rabi* season 2015-16.

### Collection of test materials

Wheat (*Triticum aestivum* L.) and *Phalaris minor* Retz. were used to test the allelopathic potential of aqueous extracts of *Chenopodium album*, *Medicago denticulata* and *Melilotus indica*. The seeds of wheat and *Phalaris minor* were collected from Norman E. Borlaug Crop Research Centre, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar. the seeds of *Phalaris minor* were of rabi season 2014-15.

### Preparation of aqueous extracts from weed samples

Biomass of the weeds collected was shade dried for one week at the shade area of Weed Agronomy block centre in Norman E. Borlaug Crop Research Centre, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar and then kept in plate dryer for 72 hours at 65±5ºC in processing laboratory. After complete drying the entire biomass was finely grinded. Grinded biomass of weed plant was weighed using electronic balance, then was well mixed in distilled water with 1: 2 (w/v) ratios and soaked for 48 hours at room temperature; the mixture was then filtered using muslin cloth. Using this method weed aqueous extracts of 50% were prepared by adding 500g of grinded sample to distilled water and making the final volume to 1.0 l. 50% of aqueous solution was further diluted by adding water to get 10% extract for application to the field. Combination treatments were prepared by mixing the sole extracts in equal amount.

### Application of weed aqueous extracts

Weed aqueous extracts were applied as pre-emergence spray to the field by battery operated sprayer 2 days after sowing.

## Results and Discussion

### Nutrient content (%)

The nitrogen, phosphorus and potassium content in grain and straw of wheat gave non-significant results under various treatments. However nitrogen content was observed higher in grain, while phosphorus and potassium content was higher in straw. Numerically, nitrogen content in grain and straw was highest under *Medicago denticulata* (10%) + *Chenopodium album* (10%) and *Medicago denticulata* (10%) + *Melilotus indica* (10%) + *Chenopodium album* (10%) respectively. *Medicago denticulata* (10%) + *Melilotus indica* (10%) + *Chenopodium album* (10%) recorded to have highest phosphorus content in grain and *Medicagodenticulata* (10%) + *Chenopodium album* (10%) in straw. Potassium content in grain was highest under *Melilotus indica* (10%) + *Chenopodium album* (10%) and in straw under control. The nitrogen, phosphorus and potassium content in straw of *Phalaris minor* was reported to be less than that in wheat, however various treatments gave non-significant results of nitrogen, phosphorus and potassium content in straw of *Phalaris minor* at harvest. Numerically, nitrogen content in straw of *Phalaris minor* was highest under *Melilotus indica* (10%) while, phosphorus and potassium content was highest under control. The data pertaining to nutrient content (%) in grain and straw of wheat is presented in Table 1 and in straw of Phalaris minor is presented in Table 2.

### Nitrogen uptake (kg/ha) by wheat and *Phalaris minor*

The variation in nitrogen uptake differ significantly under various treatments at harvest for grain and straw of wheat, straw of *Phalaris minor* as well as total. Significantly highest nitrogen uptake by wheat grain was recorded under weed free treatment (89.40 kg/ha). Nitrogen uptake by wheat straw was also recorded numerically highest (38.24 kg/ha) under weed free treatment. Nitrogen uptake by grain and straw of wheat under control condition was 49.32% and 52.03% lower than weed free condition, respectively. It clearly shows the loss of nutrients due to crop weed competition. Kanaujia (2006) [5] also mentioned the losses of nutrients due to heavy infestation of weeds.

In *Phalaris minor*, nitrogen uptake of the treatments was found at par with each other. However, numerically, highest nitrogen uptake after control in *Phalaris minor* was under *Medicago denticulata* (10%) which is an indication of higher infestation of *Phalaris minor* under this treatment compared to others.

The total uptake of nitrogen also gave significant results under various treatments with significantly highest uptake under weed free (127.65 kg/ha) which was at par with *Medicago denticulata* (10%) + *Melilotus indica* (10%) + *Chenopodium album* (10%) (115.94 kg/ha), *Medicago denticulata* (10%) + *Melilotus indica* (10%) (112.43 kg/ha) and *Melilotus indica* (10%) + *Chenopodium album* (10%) (111. 84 kg/ha). Rest treatments were at par with each other. The total nitrogen uptake has a significant share of nitrogen uptake by *Phalaris minor* and is considered as loss of nitrogen. These finding are in agreement with the work of

Abouzeina *et al.* (2008) [1] and Kumar and Agarwal (2010) [7] who observed that weeds compete very effectively with the crop for available nitrogen to the point that the reduction in yields from weed competition were generally accompanied by reduction in protein content as well.

**Phosphorus uptake (kg/ha) by wheat and *Phalaris minor***

The variation in phosphorus uptake differs significantly under various treatments at harvest for grain and straw of wheat and straw of *Phalaris minor*. Phosphorus uptake by wheat grain was recorded highest under weed free (26.96 kg/ha) at par with *Medicago denticulata* (10%) + *Melilotus indica* (10%) + *Chenopodium album* (10%) (23.52 kg/ha) while in case of straw, treatments containing *Melilotus indica* weed aqueous extracts had significantly higher uptake than other treatments. Phosphorus uptake by grain and straw of wheat under control condition was 53.56% and 54.07% lower than weed free condition, respectively. It clearly shows the loss of nutrients due to crop weed competition.

In *Phalaris minor,* all the treatments being at par with each other. However, numerically highest phosphorus uptake after control by *Phalaris minor* straw was under *Medicago denticulata* (10%).

The total uptake of phosphorus gave non-significant results under various treatments. However, highest uptake (113.78 kg/ha) was found under *Medicago denticulata* (10%) + *Melilotus indica* (10%) + *Chenopodium album* (10%).

**Potassium uptake (kg/ha) by wheat and *Phalaris minor***

The variation in potassium uptake differs significantly under various treatments at harvest for grain and straw of wheat and straw of *Phalaris minor*. Potassium uptake by wheat grain was significantly highest under weed free, rest of the treatments were at par with each other. In case of uptake by wheat straw, all treatments containing *Melilotus indica* weed aqueous extracts performed better than other treatments in terms of potassium uptake. Potassium uptake by grain and straw of wheat under control condition was 47.98% and 51.81% lower than weed free condition, respectively. It clearly shows the loss of nutrients due to crop weed competition. In *Phalaris minor*, all treatments were at par with each other. However, numerically highest potassium uptake after control in *Phalaris minor* was under *Medicago denticulata* (10%).

The total uptake of potassium gave significant results under various treatments. Treatments containing *Melilotus indica* weed aqueous extracts were recorded to have better uptake than other treatments. Percent share of wheat grain, wheat straw and *Phalaris minor* straw in total uptake of N, P and K (kg/ha) is presented in Fig. 1, 2 and 3.

*Phalaris minor* was found to have major share in total nitrogen, phosphorus and potassium uptake from soil and so led to a considerable loss of nutrients from soil which otherwise could have remained in soil enhancing its fertility status or taken up by wheat crop for better growth and development.

**Conclusion**

From the present study, it may be concluded that weeds led to heavy loss of nutrients. *Phalaris minor* had a considerable share in total nitrogen, phosphorus and potassium uptake from soil. Thus, better control of weeds is necessary for optimum utilization of available nutrient resources in which allelopathic aqueous extracts of winter weeds may play an important role and can be utilized as a tool of integrated weed management.

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**Table 1:** Effect of treatments on N, P and K content (%) of wheat grain and straw at maturity

| Treatments | N, P and K content (%) in wheat | | | | | |
|---|---|---|---|---|---|---|
| | N content | | P content | | K content | |
| | Grain | Straw | Grain | Straw | Grain | Straw |
| Control (No Application) | 1.82 | 0.63 | 0.53 | 1.38 | 1.05 | 2.05 |
| Aqueous extract of *Medicago denticulata* (10%) | 1.88 | 0.62 | 0.52 | 148 | 0.98 | 2.01 |
| Aqueous extract of *Melilotus indica* (10%) | 1.83 | 0.67 | 0.57 | 1.43 | 0.99 | 1.99 |
| Aqueous extract of *Chenopodium album* (10%) | 1.86 | 0.65 | 0.55 | 1.46 | 0.96 | 2.00 |
| Aqueous extract of (*Medicago denticulata* 10% + *Melilotus indica* 10%) | 1.87 | 0.67 | 0.57 | 1.47 | 1.00 | 2.00 |
| Aqueous extract of (*Medicago denticulata* 10% + *Chenopodium album* 10%) | 1.89 | 0.62 | 0.52 | 1.49 | 0.99 | 2.02 |
| Aqueous extract of (*Melilotus indica* 10% + *Chenopodium album* 10%) | 1.84 | 0.66 | 0.56 | 1.44 | 1.11 | 2.04 |
| Aqueous extract of (*Medicago denticulata* 10% + *Melilotus indica* 10% + *Chenopodium album* 10%) | 1.82 | 0.69 | 0.59 | 1.42 | 0.95 | 2.02 |
| Weed free | 1.82 | 0.65 | 0.55 | 1.42 | 1.02 | 2.02 |
| SEm± | 0.09 | 0.05 | 0.05 | 0.10 | 0.084 | 0.10 |
| CD (5%) | NS | NS | NS | NS | NS | NS |

NS Non-significant

**Table 2:** Effect of treatments on N, P and K content (%) of *Phalaris minor* straw at maturity

| Treatments | N, P and K content (%) in *Phalaris minor* straw | | |
|---|---|---|---|
| | N content | P content | K content |
| Control (No Application) | 1.24 (0.54) | 1.48 (1.20) | 1.34 (0.80) |
| Aqueous extract of *Medicago denticulata* (10%) | 1.24 (0.55) | 1.47 (1.81) | 1.32 (0.75) |
| Aqueous extract of *Melilotus indica* (10%) | 1.25 (0.58) | 1.47 (1.16) | 1.30 (0.76) |
| Aqueous extract of *Chenopodium album* (10%) | 1.24 (0.54) | 1.45 (1.13) | 1.32 (0.76) |
| Aqueous extract of (*Medicago denticulata* 10% + *Melilotus indica* 10%) | 1.25 (0.57) | 1.46 (1.17) | 1.32 (0.77) |
| Aqueous extract of (*Medicago denticulata* 10% + *Chenopodium album* 10%) | 1.23 (0.53) | 1.46 (1.15) | 1.33 (0.79) |
| Aqueous extract of (*Melilotus indica* 10% + *Chenopodium album* 10%) | 1.24 (0.54) | 1.47 (1.18) | 1.32 (0.77) |
| Aqueous extract of (*Medicago denticulata* 10% + *Melilotus indica* 10% + | 1.25 (0.57) | 1.45 (1.12) | 1.33 (0.78) |

| | | | |
|---|---|---|---|
| *Chenopodium album* 10%) | | | |
| Weed free | 1.00 (0.00) | 1.00 (0.00) | 1.00 (0.00) |
| SEm± | 0.058 | 0.07 | 0.06 |
| CD (5%) | NS | NS | NS |

Original values are given in parentheses

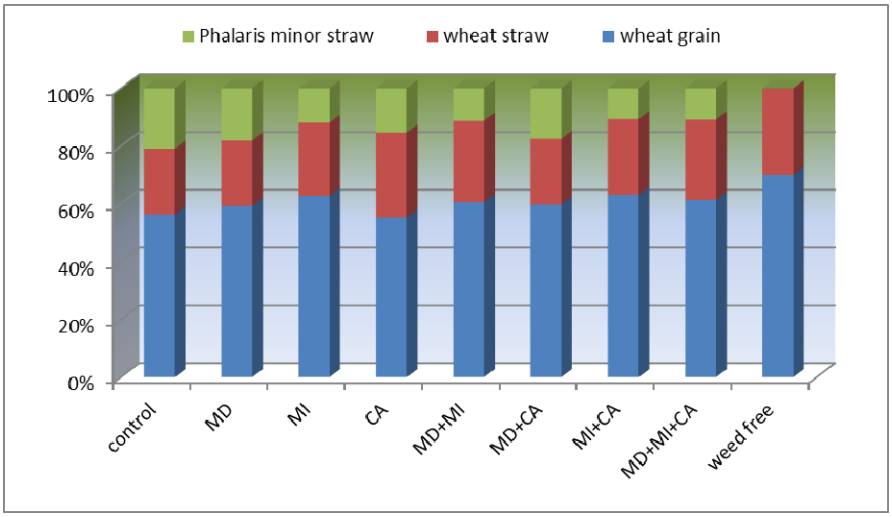


**Fig 1:** Percent share of wheat grain, wheat straw and *Phalaris minor* straw in total uptake of N (kg/ha)

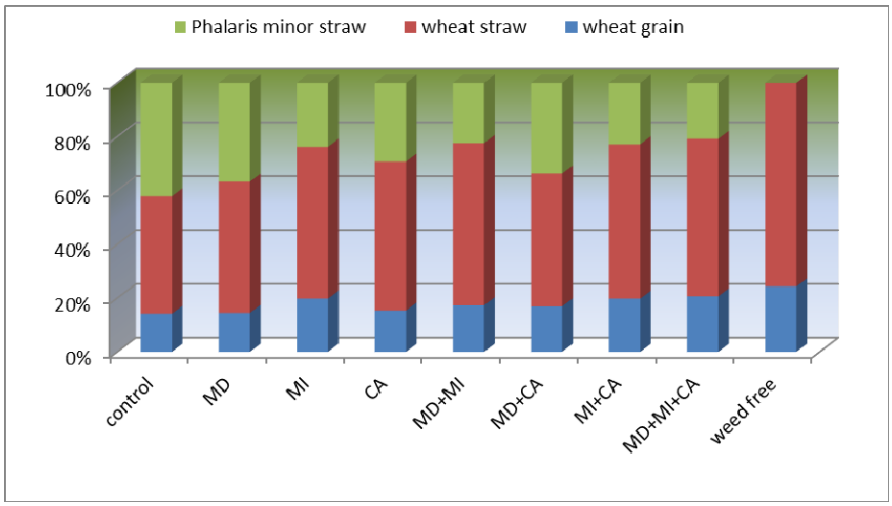


**Fig 2:** Percent share of wheat grain, wheat straw and *Phalaris minor* straw in total uptake of P (kg/ha)

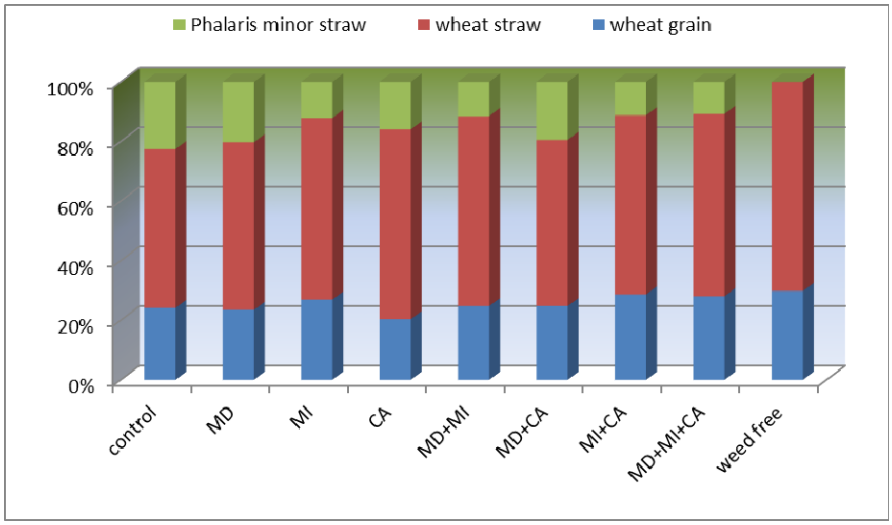


**Fig 3:** Percent share of wheat grain, wheat straw and *Phalaris minor* straw in total uptake of K (kg/ha)

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