Influence of Varieties and Herbicide Mixtures on Wheat Based Cropping System in Relation to Phytotoxicity and Residual Soil Nutrients

Sarita Rani¹*, Suresh Kumar¹, V.S. Hooda¹, and Jagdish Parshad²

¹Department of Agronomy, ²Department of Microbiology, CCS Haryana Agricultural University, Hisar- (125004), Haryana, India

*Corresponding author

A B S T R A C T

An experiment was conducted at Research Farm of CCS Haryana Agricultural University, Hisar Haryana (India) during 2014-15 and 2015-16, to study the influence of varieties and herbicide mixtures on wheat in relation to phytotoxicity and residual soil nutrients. The treatments consisting of five varieties of wheat viz., WH 1105, HD 2967, DPW 621-50, WH 1124 and DBW 17 in main plots and six weed management practices i.e. metribuzin (210 g ha⁻¹), metribuzin+fenoxaprop (150+100 g ha⁻¹), metribuzin+pinoxaden (150+40 g ha⁻¹), metribuzin+clodinafop (150+45 g ha⁻¹), weed free and weedy check in sub-plots in split plot design with three replications. All the herbicide treatments were applied at 35 days after sowing (DAS) of wheat. No phytotoxic effect of any of the herbicidal treatments was observed on crop during both years except appearance of some spots on leaves of wheat variety HD 2967 after spray in plots treated with metribuzin alone and tank mix application of metribuzin + fenoxaprop, which didn’t show any effect on yield of the crop. There was no significant effect of weed management practices on residual organic carbon (%), available P₂O₅, and K₂O during both the years, however, available soil N after crop harvest was significantly lower in weed free plots as compared to all the herbicides treated and weed free plots during both the years.

Keywords: Wheat, Metribuzin, Clodinafop, Pinoxaden, Fenoxaprop, Phytotoxicity, Soil nutrients

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Introduction

Wheat (Triticum aestivum L) is the second most important staple food crop cultivated in the world with 223.66 m ha area of cultivation, 735.26 m tonnes production with average productivity of 3290 kg/ha during 2015-16. It stands third after maize and rice in the world (USDA, 2017). It is the basic foodstuff of the developing countries and major commodity in the world food trade (Hussain et al., 2012). India is second leading country in wheat production (86.53 m tones) from an area of 31.47 m ha with an average productivity of 2750 kg/ha (USDA, 2017). Out of total 18 species of the genus Triticum, 12 are cultivated species and in India, 3 species of wheat Triticum aestivum, Triticum
durum and Triticum dicoccum are cultivated with 87, 12 and 1 percent contribution, respectively. In India, Uttar Pradesh ranks first in terms of area as well as production and Haryana ranks second after Punjab in productivity (4.4 t/ha) with 2.58 mha area and 11.35 mt production of wheat (Anonymous, 2018). The increasing demands of rising population require not only sustaining wheat production but also further increasing it with high potential. The best way to increase the wheat production is to reduce the agricultural losses with increasing production. In India, among the annual agricultural losses, weeds account for 45 per cent followed by, insects 30 per cent, diseases 20 per cent and other 5 per cent in wheat (Kler et al., 2002). So, weeds are a major problem to crop production and are accountable for maximum losses caused by all the pests. Weed competition is one of the most important constraints in crop production as weeds compete with crop plants for moisture, nutrients, light and space, thereby depriving the crop of vital inputs. (Chhokar et al., 2012). Up to 51% of reduction in grain yield in weedy check plot compared to treated plots was observed in wheat (Singh et al. 2015). Among the weed control measures, herbicidal control plays an important role in close row crops, where manual or mechanical weeding is not feasible (Yaduraju and Mishra, 2002). Mimicry grassy weeds cannot be weeded out manually or mechanically in wheat. Therefore, herbicidal control is more effective against grassy and broadleaf weeds in wheat. But continuous use of herbicide over several years certainly leads to elimination of sensitive weed species but leave out tolerant species resulting in gradual buildup of their population on account of herbicide resistance i.e. Phalaris minor against isoproturon (Malik and Singh, 1995). Due to the large scale failure of isoproturon, danger of development of rapid resistance and cross-resistance against alternate herbicides due to their continuous use, non-adoption of herbicides like pendimethalin by farmers because of its high cost and requirement for high moisture at the time of spray, phytotoxicity due to high doses of metribuzin and proportionate changes in weed flora in cereal crops necessitates using herbicide mixtures (Yadav et al., 2002; Sharma et al., 2002; Yadav and Malik, 2005; Chhipa and Nepalia, 2015).

Crop cultivars possessing traits such as fast germination, quick growth, large leaf area and high biomass have a competitive advantage over weeds. Sowing such cultivars has been shown to suppress weeds in various crops (Sardana et al., 2017). Competitive cultivars can reduce weed growth in the standing crop, curtail weed seed production, prevent future weed infestation and may serve as a low cost tool in weed management (Kumar et al., 2013). Careful selections of a competitive crop/genotype can potentially suppress weed growth without sacrificing crop yield (Ramesh et al., 2017). Cultivars of several crops including winter wheat differ considerably in their tolerance to metribuzin (Runyan et al., 1982). Differential varietal sensitivity to fenoxaprop + metribuzin has been reported (Yadav et al., 2012) and it is suggested to determine varietal sensitivity of fenoxaprop + metribuzin before use in field conditions (Yadav et al., 2016). Reduction in wheat yield by 23 percent with application of metribuzin at 210 g ha⁻¹ was reported when applied at 60 over 38 DAS (Singh et al. 2011). Choudhary et al. (2016) found lowest harvest index in metribuzin 200 g/ha as compared to all other herbicidal treatments, which was attributed to phytotoxic effect of metribuzin on wheat cultivar ‘PBW-343’. Keeping this in view present investigation was conducted to study the impact of wheat varieties and weed management practices in relation to herbicide phytotoxicity and residual soil nutrients.
Materials and Methods

An experiment was conducted during 2014-15 and 2015-16 at research farm, CCS Haryana Agricultural University, Hisar, Haryana (India) situated at 29°10' N latitude and 75°46' E longitude at an elevation of 215.2 m above mean sea level in a semi-arid climate. The upper soil layer of the experimental field was sandy loam, low in OC (0.41%) and nitrogen (212 kg/ha), medium in P2O5 (16.6 kg/ha) and high in K2O (408 kg/ha) with slightly alkaline in pH (8.3). The experiment was laid out in split plot design with three replications. The treatments consisting of five varieties of wheat viz. WH 1105, HD 2967, DPW 621-50, WH 1124 and DBW 17 in main plots and six weed management practices i.e. metribuzin (210 g ha⁻¹), metribuzin+fenoxaprop (150+100 g ha⁻¹), metribuzin+pinoxaden (150+40 g ha⁻¹), metribuzin+clodinafop (150+45 g ha⁻¹), weed free and weedy check in sub-plots. All the herbicide treatments were applied at 35 DAS of wheat, preparing herbicide combinations by tank-mixing and repeated manual weedings were practiced for maintaining the weed free plots. Fodder maize was planted after the harvest of wheat crop. The data on plant height of wheat and fodder maize, and grain yield of wheat were collected at different stages and statistically analyzed. Visual surveillance was undertaken to observe crop injury in wheat and maize. Soil analysis was done at the start and harvest of crop. The mean weekly weather data for the wheat-fodder maize cropping seasons 2014-15 and 2015-16 have been given in Fig. 1 and 2.

Results and Discussion

Herbicide phytotoxicity to wheat crop (0-10 scale)

Visual phytotoxicity (0-10 scale) recorded at 10 and 20 days after spraying indicated that there was no phytotoxic effect of any of the herbicidal treatments on crop during both years. However, some freckles/ spots appeared on leaves of wheat variety HD 2967 after spray in plots treated with metribuzin 210 g ha⁻¹ and tank mix application of metribuzin + fenoxaprop 150 + 100 g ha⁻¹, which disappeared within 1-2 weeks, and had no effect on the crop (Table 1).

Plant height (cm)

At 120 DAS, maximum plant height was recorded in wheat variety HD 2967 (97.9 cm and 94.7 cm), which was statistically at par with all varieties except DBW 17 (83.4 cm and 79.7 cm) during 2014-15 and 2015-16, respectively (Table 2). WH 1105, DPW 621-50 were at par with HD 2967 in respect of plant height during both the years. Marked differences were recorded in the plant height with different weed management practices, maximum being with the weed free treatment (96.5 and 93.8 cm during 2014-15 and 2015-16, respectively). Among herbicidal treatments, combination of metribuzin with fenoxaprop produced tallest plants and was at par with weed free plots as well as combination of metribuzin with pinoxaden or clodinafop, but significantly taller than with metribuzin applied alone and weedy check during both the years. Weedy check plots resulted in significantly lower plant height of wheat as compared to all the herbicidal treatments during both years.

Plant height of succeeding fodder maize crop at 30 DAS was statistically similar to each other in all the plots of different preceding wheat varieties and did not show any significant difference during 2014-15 and 2015-16 (Table 2). There was no significant effect of different weed management practices applied in wheat on the plant height of succeeding fodder maize crop at 30 DAS during both the years.
Grain yield (kg/ha)

Wheat variety WH 1105 proved its superiority by producing grain yield (5855 and 5401 kg ha\(^{-1}\)) during 2014-15 and 2015-16, respectively) being at par with HD 2967 and DPW 621-50, but statistically better than DBW 17 and WH 1124 (Table 2). WH 1124 showed the lowest grain yield and significantly lower than all the varieties during both the years. The weed management practices significantly influenced the wheat grain yield during both the years. The maximum grain yield was recorded in weed free plots (6284 and 5902 kg ha\(^{-1}\)) during 2014-15 and 2015-16, respectively). Weedy check plots produced the minimum grain yield (4176 and 3781 kg ha\(^{-1}\)) during 2014-15 and 2015-16, respectively) and was significantly lower than all the weed management practices. Among herbicidal treatments, metribuzin + fenoxaprop (150 + 100 g ha\(^{-1}\)) produced the maximum grain yield and it was statistically at par with weed free plots and remaining two combination treatments i.e., metribuzin + pinoxaden (150 + g ha\(^{-1}\)) and metribuzin + clodinafop (150 + 45 g ha\(^{-1}\)). Metribuzin (210 g ha\(^{-1}\)) produced significantly better grain yield as compared to weedy check, but it was inferior to combination treatments of metribuzin and other herbicides in terms of grain yield (Table 2).

**Fig.1** Mean weekly weather data for wheat-fodder maize cropping seasons 2014-15

**Fig.2** Mean weekly weather data for wheat-fodder maize cropping seasons 2015-16
### Table 1: Herbicide phytotoxicity to wheat crop (0-10 scale)

| Variety | Treatments | 2014-15 | 2015-16 |
|---------|------------|---------|---------|
|         |            | 10 DAT  | 20 DAT  | 10 DAT | 20 DAT |
| WH 1105 | MBZ 210 g ha\(^{-1}\) | 0 | 0 | 0 | 0 |
| WH 1105 | MBZ + CDF (150 + 45) g ha\(^{-1}\) | 0 | 0 | 0 | 0 |
| WH 1105 | MBZ + PDN (150 + 40) g ha\(^{-1}\) | 0 | 0 | 0 | 0 |
| WH 1105 | MBZ + FNP (150 + 100) g ha\(^{-1}\) | 0 | 0 | 0 | 0 |
| WH 1105 | Weed free | 0 | 0 | 0 | 0 |
| WH 1105 | Weedy check | 0 | 0 | 0 | 0 |
| HD 2967 | MBZ 210 g ha\(^{-1}\) | 2 | 0 | 3 | 1 |
| HD 2967 | MBZ + CDF (150 + 45) g ha\(^{-1}\) | 0 | 0 | 0 | 0 |
| HD 2967 | MBZ + PDN (150 + 40) g ha\(^{-1}\) | 0 | 0 | 0 | 0 |
| HD 2967 | MBZ + FNP (150 + 100) g ha\(^{-1}\) | 2 | 0 | 2 | 0 |
| HD 2967 | Weed free | 0 | 0 | 0 | 0 |
| HD 2967 | Weedy check | 0 | 0 | 0 | 0 |
| DPW 621-50 | MBZ 210 g ha\(^{-1}\) | 0 | 0 | 0 | 0 |
| DPW 621-50 | MBZ + CDF (150 + 45) g ha\(^{-1}\) | 0 | 0 | 0 | 0 |
| DPW 621-50 | MBZ + PDN (150 + 40) g ha\(^{-1}\) | 0 | 0 | 0 | 0 |
| DPW 621-50 | MBZ + FNP (150 + 100) g ha\(^{-1}\) | 0 | 0 | 0 | 0 |
| DPW 621-50 | Weed free | 0 | 0 | 0 | 0 |
| DPW 621-50 | Weedy check | 0 | 0 | 0 | 0 |
| WH 1124 | MBZ 210 g ha\(^{-1}\) | 0 | 0 | 0 | 0 |
| WH 1124 | MBZ + CDF (150 + 45) g ha\(^{-1}\) | 0 | 0 | 0 | 0 |
| WH 1124 | MBZ + PDN (150 + 40) g ha\(^{-1}\) | 0 | 0 | 0 | 0 |
| WH 1124 | MBZ + FNP (150 + 100) g ha\(^{-1}\) | 0 | 0 | 0 | 0 |
| WH 1124 | Weed free | 0 | 0 | 0 | 0 |
| WH 1124 | Weedy check | 0 | 0 | 0 | 0 |
| DBW 17 | MBZ 210 g ha\(^{-1}\) | 0 | 0 | 0 | 0 |
| DBW 17 | MBZ + CDF (150 + 45) g ha\(^{-1}\) | 0 | 0 | 0 | 0 |
| DBW 17 | MBZ + PDN (150 + 40) g ha\(^{-1}\) | 0 | 0 | 0 | 0 |
| DBW 17 | MBZ + FNP (150 + 100) g ha\(^{-1}\) | 0 | 0 | 0 | 0 |
| DBW 17 | Weed free | 0 | 0 | 0 | 0 |
| DBW 17 | Weedy check | 0 | 0 | 0 | 0 |

Abbreviations: MBZ, metribuzin; CDF, clodinafop; PDN, pinoxaden; FNP, fenoxaprop;
Table 2 Effect of different weed control treatments on plant height of wheat, grain yield 2014-15 and 2015-16

| Treatments          | Plant height wheat (cm) at 120 DAS | Plant height maize (cm) at 30 DAS | Wheat grain yield (kg ha\(^{-1}\)) |
|---------------------|-----------------------------------|----------------------------------|---------------------------------|
|                     | 2014-15  | 2015-16  | 2014-15  | 2015-16  | 2014-15  | 2015-16  |
| A. Varieties        |          |          |          |          |          |          |
| WH 1105             | 95.9     | 94.3     | 65.5     | 64.3     | 5855     | 5401     |
| HD 2967             | 97.9     | 94.7     | 64.2     | 64.1     | 5778     | 5297     |
| DPW 621-50          | 96.6     | 93.0     | 67.1     | 67.5     | 5701     | 5222     |
| WH 1124             | 95.2     | 92.3     | 66.6     | 67.3     | 5153     | 4782     |
| DBW 17              | 83.4     | 79.7     | 64.2     | 65.3     | 5460     | 5048     |
| SEm±                | 0.9      | 1.0      | 1.7      | 1.6      | 67       | 79       |
| CD (5%)             | 2.8      | 3.0      | NS       | NS       | 223      | 261      |
| B. Weed Management  |          |          |          |          |          |          |
| MBZ 210 g ha\(^{-1}\) | 93.0     | 89.9     | 65.0     | 64.9     | 5153     | 4733     |
| MBZ + CDF (150 + 45) g ha\(^{-1}\) | 94.0     | 90.7     | 65.4     | 64.5     | 5926     | 5436     |
| MBZ + PDN (150 + 40) g ha\(^{-1}\) | 94.9     | 91.7     | 65.2     | 65.2     | 5967     | 5501     |
| MBZ + FNP (150 + 100) g ha\(^{-1}\) | 95.8     | 92.5     | 65.2     | 65.8     | 6032     | 5547     |
| Weed free           | 96.5     | 93.8     | 66.4     | 66.4     | 6284     | 5902     |
| Weedy check         | 88.5     | 86.2     | 65.9     | 67.2     | 4176     | 3781     |
| SEm±                | 0.8      | 0.7      | 1.2      | 1.2      | 139      | 165      |
| CD (5%)             | 2.3      | 2.1      | NS       | NS       | 397      | 469      |
Table 3: Effect of varieties and weed management practices in wheat on organic carbon and N, P, K availability in soil

| Treatments | OC (%) | Available N (kg ha\(^{-1}\)) | Available P\(_{2}O_{5}\) (kg ha\(^{-1}\)) | Available K\(_{2}O\) (kg ha\(^{-1}\)) |
|------------|--------|-------------------------------|---------------------------------|---------------------------------|
| **2014-15** |        |                               |                                 |                                 |
| **A. Varieties** |        |                               |                                 |                                 |
| WH 1105      | 0.35   | 205.6                         | 14.6                            | 402.0                           |
| HD 2967      | 0.36   | 207.3                         | 15.1                            | 397.0                           |
| DPW 621-50   | 0.37   | 209.3                         | 15.6                            | 406.0                           |
| WH 1124      | 0.41   | 212.6                         | 16.5                            | 410.0                           |
| DBW 17       | 0.40   | 212.0                         | 16.2                            | 408.0                           |
| SEm±         | 0.20   | 1.1                           | 0.7                             | 4.3                             |
| CD (5%)      | NS     | 3.2                           | NS                              | NS                              |
| **B. Weed Management** |        |                               |                                 |                                 |
| MBZ 210 g ha\(^{-1}\) | 0.38   | 211.4                         | 16.3                            | 409.0                           |
| MBZ + CDF (150 + 45) g ha\(^{-1}\) | 0.37   | 209.8                         | 15.9                            | 407.0                           |
| MBZ + PDN (150 + 40) g ha\(^{-1}\) | 0.37   | 208.9                         | 15.3                            | 404.0                           |
| MBZ + FNP (150 + 100) g ha\(^{-1}\) | 0.39   | 208.1                         | 15.1                            | 402.0                           |
| Weed free   | 0.41   | 205.3                         | 14.4                            | 395.0                           |
| Weedy check | 0.36   | 212.5                         | 16.6                            | 410.0                           |
| SEm±        | 0.20   | 2.1                           | 0.8                             | 4.3                             |
| CD (5%)     | NS     | 6.0                           | NS                              | NS                              |
| **2015-16** |        |                               |                                 |                                 |
| **A. Varieties** |        |                               |                                 |                                 |
| WH 1105      | 0.34   | 203.1                         | 14.7                            | 399.0                           |
| HD 2967      | 0.35   | 204.2                         | 15.3                            | 395.0                           |
| DPW 621-50   | 0.36   | 207.7                         | 15.5                            | 403.0                           |
| WH 1124      | 0.40   | 212.1                         | 16.8                            | 407.0                           |
| DBW 17       | 0.40   | 211.1                         | 16.3                            | 406.0                           |
| SEm±        | 0.20   | 1.4                           | 0.8                             | 4.2                             |
| CD (5%)     | NS     | 4.2                           | NS                              | NS                              |
| **B. Weed Management** |        |                               |                                 |                                 |
| MBZ 210 g ha\(^{-1}\) | 0.36   | 211.2                         | 16.4                            | 406.0                           |
| MBZ + CDF (150 + 45) g ha\(^{-1}\) | 0.37   | 208.9                         | 16.0                            | 405.0                           |
| MBZ + PDN (150 + 40) g ha\(^{-1}\) | 0.38   | 206.4                         | 15.4                            | 401.0                           |
| MBZ + FNP (150 + 100) g ha\(^{-1}\) | 0.38   | 205.3                         | 15.2                            | 398.0                           |
| Weed free   | 0.40   | 201.1                         | 14.5                            | 394.0                           |
| Weedy check | 0.35   | 212.9                         | 16.8                            | 408.0                           |
| SEm±        | 0.20   | 3.1                           | 0.9                             | 4.6                             |
| CD (5%)     | NS     | 9.4                           | NS                              | NS                              |
Residual nutrients in soil

Soil analysis data (Table 3) taken at harvest of crop revealed that no significant difference due to any of the varieties or weed management practices was observed on organic carbon (%), available P₂O₅ and K₂O during both the years, however, available N was significantly affected by the treatments. Maximum available nitrogen was found in plots where wheat variety WH 1124 (212.6 and 212.1 kg ha⁻¹) was grown being at par with DBW 17 and differed significantly from the plots of rest of wheat varieties during 2014-15 and 2015-16, respectively. Availability of soil nitrogen was significantly lower in weed free plots as compared to plots with metribuzin application and weedy check plots during both the years. Weedy check plots recorded highest available nitrogen (212.5 and 211.9 kg ha⁻¹) during 2014-15 and 2015-16, respectively.

In conclusion, any of the herbicide treatment did not exhibit serious phytotoxicity to any of the wheat varieties (except minor effect on variety HD 2967 which recovered quickly and didn’t affect the plant height and grain yield) in experiment however herbicidal sensitivity needs to be determined before using in the field conditions. There was no significant effect of weed management practices on residual organic carbon (%), available P₂O₅, and K₂O during both the years.

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