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Response of strip-planted wheat varieties to pendimethalin

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ABSTRACT

The study was initiated with the aims to determine the variation in growth and yield of winter wheat varieties to pendimethalin at different application rates and to identify the wheat varieties tolerant or susceptible to pendimethalin. A two-year study was conducted on sandy clay loam textured soil containing low organic matter content during the dry season having no or very little amount of rainfall. Eight wheat varieties (BARI Gom 21 to 28) were tested against pendimethalin 33EC applied at its label rate (3 L ha^{-1}), double (6 L ha^{-1}) and three times of the label rate (9 L ha^{-1}). Emergence of all wheat varieties was not adversely affected by pendimethalin even applied at three times higher than the label rate; however, plant heights of BARI Gom 23 and BARI Gom 25 were slightly decreased with increasing application rate. Label rate application of pendimethalin did not decrease the yields of all wheat varieties compared to the control, but BARI Gom 21, BARI Gom 22, BARI Gom 24, BARI Gom 26 and BARI Gom 27 gave their best yields at three times higher of the label rate application. Therefore, the study marked out BARI Gom 21, BARI Gom 22, BARI Gom 24, BARI Gom 26 and BARI Gom 27 as the pendimethalin-tolerant wheat varieties under strip planting system. Additionally, the study confirmed that all the wheat varieties were tolerant to label rate application of pendimethalin; however, BARI Gom 23, BARI Gom 25 and BARI Gom 28 were susceptible to the higher rate of pendimethalin.

Keywords: Herbicide, minimum tillage, plant growth, tolerance, wheat

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1 Introduction

Wheat is the most important cereal crop throughout the world and this is the third most important crop of Bangladesh that occupies 4.45 million hectares of land with an average yield of 3.031 h ha^{-1} (BBS, 2017). According to BARC (2018), 7.27 million hectares of land of Bangladesh are suitable for growing wheat. Before the year of 1971 people of the country were not habituated to intake wheat; but later on the consumption level has increased. In this regard, the role of Wheat Research Center of Bangladesh Agricultural Research Institute (Current name Wheat and Maize Research Institute) is appreciable because this institute has been released many potential high yielding wheat varieties since 1972 to meet up wheat demand for the increasing population of the country (Hossain and da Silva, 2012). Farmers are now interested to grow strip-planted wheat instead of conventional wheat because of higher yield as well as better soil health (Gathala et al., 2011; Hossain et al., 2014; Alam et al., 2014). But, to attain the maximum wheat yield, good agronomic crop management must to be ensured. Weed management is an integral part of good crop management and it is essential at the early growing stage of wheat to achieve the target yield. Manual weeding is a common means of controlling

weeds in our country, but this practice demands high labour force that may increase the tension of farmers due to unavailability of labours on time and also increases cost of production due to very high wages of labour. Mechanical weeding can be the alternative of manual weeding for controlling weeds, but get bound between the crop rows. Therefore, weeds that emerged within the row near the crop zone remain undisturbed by mechanical weeding and crop-weed competition reaches at the peak. On the other side, by using selective chemical (herbicide) emerged weeds at the crop row or between the rows can be killed. Therefore, now-a-days farmers are showing their interest to use herbicide for managing weeds. At present, 696 commercial herbicide products of 52 chemicals are being registered in Bangladesh (BCPA, 2018); however, among those pendimethalin is the only pre-emergence herbicide for wheat that is available in the market and farmers are usually using it for controlling weeds in wheat (Hossain and da Silva, 2012).

Pendimethalin ($C_{13}H_{19}N_3O_4$), a dinitroaniline herbicide, is usually used in corn, wheat, rice, potato, soybean, onion, garlic, tomato, cabbage and pepper as pre-emergent and post-emergent to get rid of annual grasses and some broadleaf weeds (Lin et al., 2007). The available form of this herbicide in our country is pendimethalin 33EC (BCPA, 2018). Generally, farmers are being suggested to use herbicide at the label rate, but very often they are used to apply herbicide more than the label rate. Sometimes the highly and densely weed infested wheat field also demands application of herbicide at higher rate. Considering this issue, it is highly needed to test the effect of higher rate of pendimethalin on wheat before prescribing the farmers. Moreover, the response of wheat varieties can vary with the herbicides or even with the rates of same herbicide (Dhammu and Nicholson, 2006). The response of wheat varieties to pendimethalin at label rate or higher rate has not yet been evaluated under Bangladesh condition. Therefore, the study was conducted s to evaluate the effect of pendimethalin on commonly used wheat varieties at different rates and also to find out the pendimethalin tolerant and susceptible wheat varieties under strip-planting system.

2 Materials and Methods

A trial was conducted under weed-free field condition for two-years at the Agronomy Field Laboratory of Bangladesh Agricultural University, Mymensingh, Bangladesh located at 24°43′8.3″N, 90°25′41.2″E (elevation of 19 meters above sea level and in the south-west part of old Brahmaputra) during 2013 and 2014. The paddock was medium high land with sandy clay loam textured soil having pH of 6.8 and organic matter content of 1.74%. During the study period, the crop experienced low air temperature with scanty rainfall and also short day length from the emergence to flowering stage during November to February. The air temperature started to increase from the month of March and the increasing trend was prevailed up to the crop maturity. Soil temperature at 5 and 10 cm depth were ranged between 19.9-29.6 °C and 19.3-25.3 °C during the crop growing period of 2013-14 and 20.3-30.1 °C and 19.9-28.6 °C during 2014-15, respectively. The crop received total 54.5 mm of rainfall during 2013-14 and 35.5 mm during 2014-15 up to harvest. Therefore, additional 3-4 light irrigations were provided to ensure proper crop growth. From the next month of crop harvest, the amount of monthly total rainfall was started to increase. The relative humidity during both the year was at the peak in the month of December.

Eight wheat varieties *viz.*, BARI Gom 21, BARI Gom 22, BARI Gom 23, BARI Gom 24, BARI Gom 25, BARI Gom 26, BARI Gom 27 and BARI Gom 28 were tested against pendimethalin (Trade name – Panida33EC) at the rate of 3, 6 or 9 L ha^{-1}. Crop performance of each wheat variety in pendimethalin treated plots was compared with the untreated control plots. The experiment was laid out in a strip-plot design with three replications. Wheat varieties were allocated in the separate strips having the size of each strip 1 m $\times$ 14 m and herbicide treatments were arranged within the strip-plot having the unit plot size of 12.5 m $\times$ 3.5 m.

The experimental field was made weed-free by application of pre-planting herbicide Roundup® (glyphosate 41% SL- IPA salt) @ 76 mL per 10 L of water for two times at 15 day intervals. After 2 days of second time Roundup application, seeds of all wheat varieties were continuous sown within the strip of 20 cm apart made by Versatile Multi-crop Planter (VMP) on 21 November 2013 and 22 November 2014. At the time of wheat seeding, the land was fertilized with phosphorus, potassium and sulphur with the help of VMP machine @ 64, 24 and 13 kg ha^{-1} in the form of triple super phosphate, muriate of potash and gypsum, respectively. Additionally, cow dung was incorporated at the rate of 7 t ha^{-1} before strip tilled the soil. Nitrogen fertilizer was broadcast @ 84 kg ha^{-1} in the form of urea in two equal installments at 15 and 35 days after sowing (DAS). Pendimethalin was sprayed on 25 November 2013 and 24 November 2014 as per treatment required rate. Manual weeding was done in the control plots whenever weed emerged. Even manual weeding was also done in the pendimethalin treated plots to keep the plots weed-free during the whole crop growing period to get only the effect of pendimethalin on wheat plants. The crop was irrigated 3 times and the first irrigation was applied lightly at Z5 stage of wheat just for wetting soil surface. The second irrigation was provided at Z15 stage and the third irrigation was given at Z35 stage. Phytotoxic effect of pendimethalin on wheat plants (leaf

bleaching or yellowing, burning of leaf tip, leaf rotten, stunting growth, etc.) was visually assessed from 3 days to 15 days after herbicide application. The degree of toxicity was measured by the scale used by International Rice Research Institute (IRRI). The rating of toxicity was done for three times at 3, 7 and 15 days after herbicide application and the mean value was calculated from the rating of 15 sample plants of a unit plot. According to the toxicity rating, 1 = no phytotoxicity, 2 = slight to moderate toxicity (leaf yellowing and stunted growth, recovered within 15 days), 3 = moderate to severe toxicity (leaf yellowing and stunted growth, recovered within 25-35 days), 4 = severe toxicity (leaf yellowing and stunted growth, not recovered), 5 = all plants died. Plant heights of each of the wheat varieties from the herbicide treated plots and the control plots were measured from randomly selected five plants of each plot at 25, 40 and 55 DAS and at harvest. SPAD-502 plus meter was used to quantify leaf greenness of all wheat varieties in pendimethalin treated plots comparing with the controlled plots and expressed as SPAD (Silicon Photon Activated Diode) value. Above ground wheat biomass for all the varieties was recorded from 1 m^2 area. Wheat varieties were harvested at their maturity. During the first year, BARI Gom 23, BARI Gom 26 and BARI Gom 28 were harvested on 18 March 2014 and the rest varieties were harvested on 25 March 2014. In the second year, BARI Gom 24 and BARI Gom 28 harvested on 11 March 2015 and rest of the varieties (BARI Gom 21, BARI Gom 22, BARI Gom 23, BARI Gom 25, BARI Gom 26 and BARI Gom 27) harvested on 16 March 2015. The crop was harvested from the central 2 m^2 area of each plot and straw and grain yields of all the varieties were converted into ton per hectare. Grain yield was adjusted at 12% moisture.

Germination index (GI) was calculated by using the following formula as suggested by Scott et al. (1984).

$$GI = \frac{\sum T_i N_i}{S} \quad (1)$$

Where, GI = germination index, T_i is the number of days after planting, N_i the number of seeds germinated on day i, and S is the number of planted seeds.

Data were statistically analyzed by using the open source statistical program 'R' (version 3.3.3). Means of the treatments were compared according to the Tukey's Honest Significant Difference (HSD) test.

3 Results

3.1 Herbicide toxicity on wheat

The phytotoxic effect of pendimethalin was visually observed during 2013-14 and 2014-15. Results showed that pendimethalin exerted no phytotoxic effect on any of the eight wheat varieties in any year (data not shown). However, during 2014-15, germination of BARI Gom-23 was slightly hampered at double and triple of the level rate application of pendimethalin.

3.2 Germination and plant population

The interaction effect of variety and herbicide rate on germination index of wheat was significant during both the year. Plant population of wheat at 15 days after sowing (DAS) was also significantly affected by the interaction effect but only during 2014-15 (Tables 1 and 2). During 2013-14, plant population was significantly varied only with the varieties but not with the herbicide rates. Germination indices of the pendimethalin treated plots at the label rate and at higher than label rates were better than that of non-treated control plots for all the tested wheat varieties except BARI Gom 23 that had significantly lower germination index at three times higher label rate during 2013-14 and at all the tested rates of pendimethalin during 2014-15 (Tables 1 and 2). BARI Gom 27 also had lower germination index at three times higher than the label rate of pendimethalin in comparison to the control.

In case of plant population, BARI Gom 21 gave the highest number of wheat plants m^{-2} during 2013-14 and BARI Gom 28 during 2014-15 (Tables 3 and 4). During 2014-15, BARI Gom 21, BARI Gom 24, BARI Gom 26 and BARI Gom 28 produced higher number of plants in pendimethalin treated plots at the label rate and at higher than the label rates compared to the control plots, while BARI Gom 22 and BARI Gom 23 had higher number of plants m^{-2} in the control plots than the pendimethalin treated plots. All the wheat varieties produced similar number of plants at label rate application of pendimethalin with the non-treated control except BARI Gom 23 and BARI Gom 28. Plots treated with pendimethalin at the label rate had less number of plants for BARI Gom 23 by 21.2% and more number of plants for BARI Gom 28 by 11.8% compared to the untreated plots, respectively.

3.3 Plant height

In 2013-14, the interaction effect of variety and rate of pendimethalin on plant height of wheat was significant at 25 days after sowing (DAS) but not at 40 and 55 DAS and at harvest (Fig. 1). On the contrary, during 2014-15, the height of wheat plants at 25 and 40 DAS were not significantly affected by the interaction of variety and pendimethalin rate while plant height at 55 DAS and at harvest were significantly affected by their interaction. During 2013-14, BARI Gom 22 treated with pendimethalin at three times of the label rate had the tallest plants (20.8 cm) at 25 DAS (Fig. 1).

Table 1. Effect of variety and rate of pendimethalin on germination index (%) of wheat varieties under strip tillage system during 2013-14

Treatments	Control	P (1×)	P (2×)	P (3×)	Varietal effect
BARI Gom 21	23.18 bc	24.52 ab	25.28 a	22.84 cd	23.96 A
BARI Gom 22	13.26 lm	14.19 l	13.13 lm	12.30 m	13.22 D
BARI Gom 23	20.94 f-i	21.10 e-i	20.03 h-k	19.03 jk	20.28 C
BARI Gom 24	20.08 h-k	20.89 f-i	20.74 ghi	21.23 d-i	20.74 BC
BARI Gom 25	21.62 c-h	22.63 cde	22.09 c-g	21.74 c-g	22.02 B
BARI Gom 26	20.74 ghi	22.18 c-g	22.07 c-g	22.42 c-f	21.85 B
BARI Gom 27	19.89 ijk	22.78 cd	21.00 e-i	20.68 g-j	21.09 BC
BARI Gom 28	18.97 k	20.82 f-i	22.14 c-g	22.24 c-g	21.04 BC
Herbicidal effect	19.79 B	20.97 A	20.72 A	20.61 A	
$LSD_{0.05}$	Variety: 1.36; Herbicide: 0.70; Variety × Herbicide: 1.65				
CV(%)	Variety: 7.57; Herbicide: 4.84; Variety × Herbicide: 4.74				

P = Pendimethalin; Means with the same letter are not significantly different as per LSD test

Table 2. Effect of variety and rate of pendimethalin on germination index (%) of wheat varieties under strip tillage system during 2014-15

Treatments	Control	P (1×)	P (2×)	P (3×)	Varietal effect
BARI Gom 21	15.78 ijk	15.93 ijk	16.54 hij	17.49 ghi	16.44 E
BARI Gom 22	17.04 hi	17.06 hi	16.98 hi	17.08 hi	17.04 DE
BARI Gom 23	23.77 abc	18.18 fgh	14.96 jkl	14.16 klm	17.77 CD
BARI Gom 24	11.43 n	13.05 lmn	13.81 lm	16.03 ijk	13.58 F
BARI Gom 25	19.67 ef	21.47 de	19.36 fg	19.32 fg	19.96 B
BARI Gom 26	12.79 mn	13.12 mn	14.47 klm	14.93 jkl	13.83 F
BARI Gom 27	19.04 fg	19.54 f	18.12 fgh	16.98 hi	18.42 C
BARI Gom 28	22.42 cd	25.68 a	24.46 ab	22.72 bcd	23.82 A
Herbicidal effect	17.74	18	17.33	17.34	
$LSD_{0.05}$	Variety: 1.08; Variety×Herbicide: 1.93				
CV(%)	Variety: 8.72; Herbicide: 6.77; Variety×Herbicide: 6.67				

P = Pendimethalin; Means with the same letter are not significantly different as per LSD test

This variety had similar height of plants in the plots treated with pendimethalin at double of the label rate (18.9 cm) and label rate (18.2 cm) and also in control plots (18.7 cm). Moreover, at 40 and 55 DAS and at harvest, the tallest plants of almost all the wheat varieties (except BARI Gom 23 and BARI Gom 24) were observed in the plots treated with pendimethalin with label rate (Fig. 1). During 2014-15, the tallest plants at 55 DAS were observed in BARI Gom 28 treated with pendimethalin at label rate while the tallest plants at harvest were recorded with untreated BARI Gom 23 (Fig. 2). In addition, all wheat varieties had taller plants in pendimethalin treated plots compared to the control plots; however, exception was found in BARI Gom 23 that had taller plants in control plots.

3.4 SPAD value of wheat leaves

The interaction effect of variety and pendimethalin rate on leaf chlorophyll content (SPAD value) of wheat was significant ($p<0.001$) at 25 DAS during 2013-14 but not at 40 and 55 DAS (Data not shown). The highest SPAD value at 25 DAS of wheat was recorded in BARI Gom28 treated with pendimethalin at the label rate. On the other hand, the lowest SPAD value at 25 DAS was obtained from the untreated BARI Gom22. At 40 and 55 DAS, leaf chlorophyll contents were significantly varied ($p<0.001$) with the varieties but not with the rate of pendimethalin (Data not shown). BARI Gom26 had the highest SPAD value at 40 DAS and the identical result was also found in BARI Gom27, BARI Gom24 and BARI Gom28. The lowest SPAD value at 40 DAS was recorded from BARI Gom21. At 55 DAS, leaves of BARI Gom28 had the highest SPAD value whereas BARI Gom25 had the lowest value. During 2014-15, the interaction effects of variety and pendimethalin rate on leaf chlorophyll contents at 25, 40 and 55 DAS were non-significant (Data not shown); however, the main effects of variety and rate of pendimethalin were significant. Leaves of

Table 3. Effect of variety on number of plant population (m^{-2}) at 15 days after sowing of wheat varieties under strip tillage system during 2013-14

Treatments	Control	P (1×)	P (2×)	P (3×)	Varietal effect
BARI Gom 21	212.3	209	214.7	216.7	213.2 A
BARI Gom 22	117.7	128.3	118	117.3	120.3 D
BARI Gom 23	198.3	199	194.7	188	195.0 BC
BARI Gom 24	185.7	191	191.3	193.3	190.3 BC
BARI Gom 25	202	206.3	196	195	199.8 B
BARI Gom 26	191.7	195.3	198.7	205.3	197.8 BC
BARI Gom 27	178.3	197	187.7	184.3	186.8 C
BARI Gom 28	174	186	198.3	194.3	188.2 BC
Herbicidal effect	182.5	189	187.4	186.8	
$LSD_{0.05}$	Variety: 12.76				
CV(%)	Variety: 7.29; Herbicide: 8.32; Variety×Herbicide: 6.18				

P = Pendimethalin; Means with the same letter are not significantly different as per LSD test

Table 4. Effect of variety on number of plant population (m^{-2}) at 15 days after sowing of wheat varieties under strip tillage system during 2014-15

Treatments	Control	P (1×)	P (2×)	P (3×)	Varietal effect
BARI Gom 21	143.0 j-n	144.3 j-n	147.3 j-m	155.3 f-k	147.5 D
BARI Gom 22	156.0 f-k	153.3 h-k	153.7 g-k	151.0 i-l	153.5 CD
BARI Gom 23	211.0 ab	166.3 e-i	136.0 l-o	131.0 nop	161.1 C
BARI Gom 24	103.0 q	118.0 pq	120.7 op	141.3 k-n	120.8 E
BARI Gom 25	174.0 de	186.0 cd	169.7 ef	169.3 efg	174.8 B
BARI Gom 26	116.7 pq	117.7 pq	130.3 nop	132.3 m-p	124.3 E
BARI Gom 27	169.0 e-h	169.7 ef	157.7 f-j	147.3 j-m	160.9 C
BARI Gom 28	196.7 bc	220.0 a	209.0 ab	199.7 bc	206.3 A
Herbicidal effect	158.7	159.4	153	153.4	
$LSD_{0.05}$	Variety: 9.96; Variety×Herbicide: 15.91				
CV(%)	Variety: 7.29; Herbicide: 8.32; Variety×Herbicide: 6.18				

P = Pendimethalin; Means with the same letter are not significantly different as per LSD test

BARI Gom28 had the highest SPAD value and BARI Gom23 had the lowest one. In case of pendimethalin, plants treated with label rate had the highest SPAD value at 25 DAS while plants treated with three times higher of the label rate had the highest SPAD value at 40 and 55 DAS. The lowest SPAD values of wheat leaves at 25, 40 and 55 DAS were recorded from the untreated plants.

3.5 Tillering and head formation

The interaction effects of variety and rate of pendimethalin on numbers of wheat tillers and heads were significant during both the year (Figs. 3 and 4). BARI Gom 21 produced the highest number of tillers m^{-2} at three times of the label rate application of pendimethalin during both years. In case of heads m^{-2}, the highest number was also counted from BARI Gom 21 treated with three times of the label rate of pendimethalin during 2013-14 whereas BARI Gom 24 produced the highest number heads during 2014-15 when treated with three times of the label rate of pendimethalin. The lowest number of tillers and heads were counted from the control plots of BARI Gom 26 during 2013-14 and from the control plots of BARI Gom 28 during 2014-15, respectively (Figs. 3 and 4).

3.6 Grain and straw yields

Grain and straw yields (t ha^{-1}) of strip-tilled wheat were significantly ($p<0.001$) affected by the interaction of variety and pendimethalin rate during both years (Figs. 3 and 4). The highest grain yields of most of the wheat varieties were obtained from three times of the label rate application of pendimethalin except BARI Gom 23, BARI Gom 25 and BARI Gom 28 as these varieties gave the highest yield at label rate application of pendimethalin. Application of pendimethalin at three times of the label rate offered

the highest grain yield production in BARI Gom 26 during both years (Figs. 3 and 4). On the other hand, control plots of BARI Gom 25 produced the lowest grain yield. Variety-wise yearly grain yield of the untreated control plots ranged between 3.15and 3.82 for BARI Gom 21, 2.96and 3.20 for BARI Gom 22, 2.61 and3.18 for BARI Gom 23, 2.66 and3.83 for BARI Gom 24, 2.43 and 2.45 for BARI Gom 25, 3.41 and 4.09 for BARI Gom 26, 2.78 and 3.01 for BARI Gom 27 and 3.65 and 3.89 for BARI Gom 28. Two-year results demostrated that pendimethalin treated plots of all the wheat varieties had higher grain yield (BARI Gom 21: 6-30%; BARI Gom 22: 9-32%; BARI Gom 23: 4-27%; BARI Gom 24: 14-41%; BARI Gom 25: 8-43%; BARI Gom 26: 17-52%; BARI Gom 27: 3-22% and BARI Gom 28: 5-21%) compared to the control plots (Figs. 3 and 4).

In case of straw, the highest yield was gained from BARI Gom 21 treated with three times label rate of pendimethalin during 2013-14 and similar yield was also offered by BARI Gom 24 at three times application of pendimethalin (Figs. 3 and 4). In 2014-15, BARI Gom 24 produced the highest straw yield at three times of the label rate application of pendimethalin. During both years, the lowest straw yield producer was the untreated BARI Gom 25. All wheat varieties produced significantly higher straw yield (BARI Gom 21: 11-26%, BARI Gom 22: 20-42%; BARI Gom 23: 4-17%; BARI Gom 24: 9-34%; BARI Gom 25: 6-25%; BARI Gom 26: 10-32%; BARI Gom 27: 1-15% and BARI Gom 28: 9-17%) at pendimethalin treated plots compared to the control plots.

4 Discussion

Pendimethalin had no visual phytotoxic effect on any of the wheat varieties at its level rate or even at three times higher than the label rate. Pendimethalin is usually applied as a pre-emergence herbicide to control annual grasses and some broad-leaved weeds of wheat, corn, soybean, potato and in some other crops (Alshallash, 2014; Lin et al., 2007); but there is no evidence that pendimethalin has any phytotoxic effect on wheat. The study demonstrated that germination index and plant population of BARI Gom 23 were significantly affected by three times higher of the label rate application of pendimethalin. The reason is not clear and however, there is a scope to further study on this variety with different rates of pendimethalin under different soils and climatic conditions. An earlier study with barley reported that the effect of pendimethalin on plant population was quite severe and the number of barley plants was decreased by more than 50% after application of pendimethalin at 0.25 kg a.i. ha^{-1} compared to 0.125 kg a.i. ha^{-1} (Alshallash, 2014).

Application of pendimethalin at label rate, double or triple of the label rate offered similar or sometimes taller plants for any of the wheat varieties compared to the non-treated control. This is an indication that plant height of none of the wheat varieties was adversely affected by pendimethalin. However, in case of Barley, (Alshallash, 2014) reported that pendimethalin reduced plant size. The study demonstrated that leaf greenness (SPAD values) of all wheat varieties were not adversely affected by application of pendimethalin at label rate or even at three times higher than the label rate. This result might be a good indication of having no adverse effect of pendimethalin on photosynthesis of leaves of all wheat varieties. Except BARI Gom 23, BARI Gom 25 and BARI Gom 28, all the wheat varieties produced the highest number of tillers and heads as well as the highest grain and straw yields. Whereas, BARI Gom 23, BARI Gom 25 and BARI Gom 28 had the highest grain and straw yields in the plots with pendimethalin at label rate application as these plots produced the highest number of tillers and heads.

5 Conclusions

Application of pendimethalin at label rate was tolerable to all the tested wheat varieties. The study identified BARI Gom 21, BARI Gom 22, BARI Gom 24, BARI Gom 26 and BARI Gom 27 as the tolerant wheat varieties to pendimethalin that provided their highest grain and straw yields at three times higher of the label rate application of this pre-emergence herbicide. On the other side, BARI Gom 23, BARI Gom 25 and BARI Gom 28 were slightly susceptible to double and triple of the label rate application of pendimethalin as their yields decreased compared to the label rate application of pendimethalin and plant heights of these varieties were also found affected at the early stage of crop growth. Therefore, the study concludes that label rate application of pendimethalin is safe for all the tested varieties and BARI Gom 21, BARI Gom 22, BARI Gom 24, BARI Gom 26 and BARI Gom 27 were the pendimethalin tolerant winter wheat varieties.

Conflict of Interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

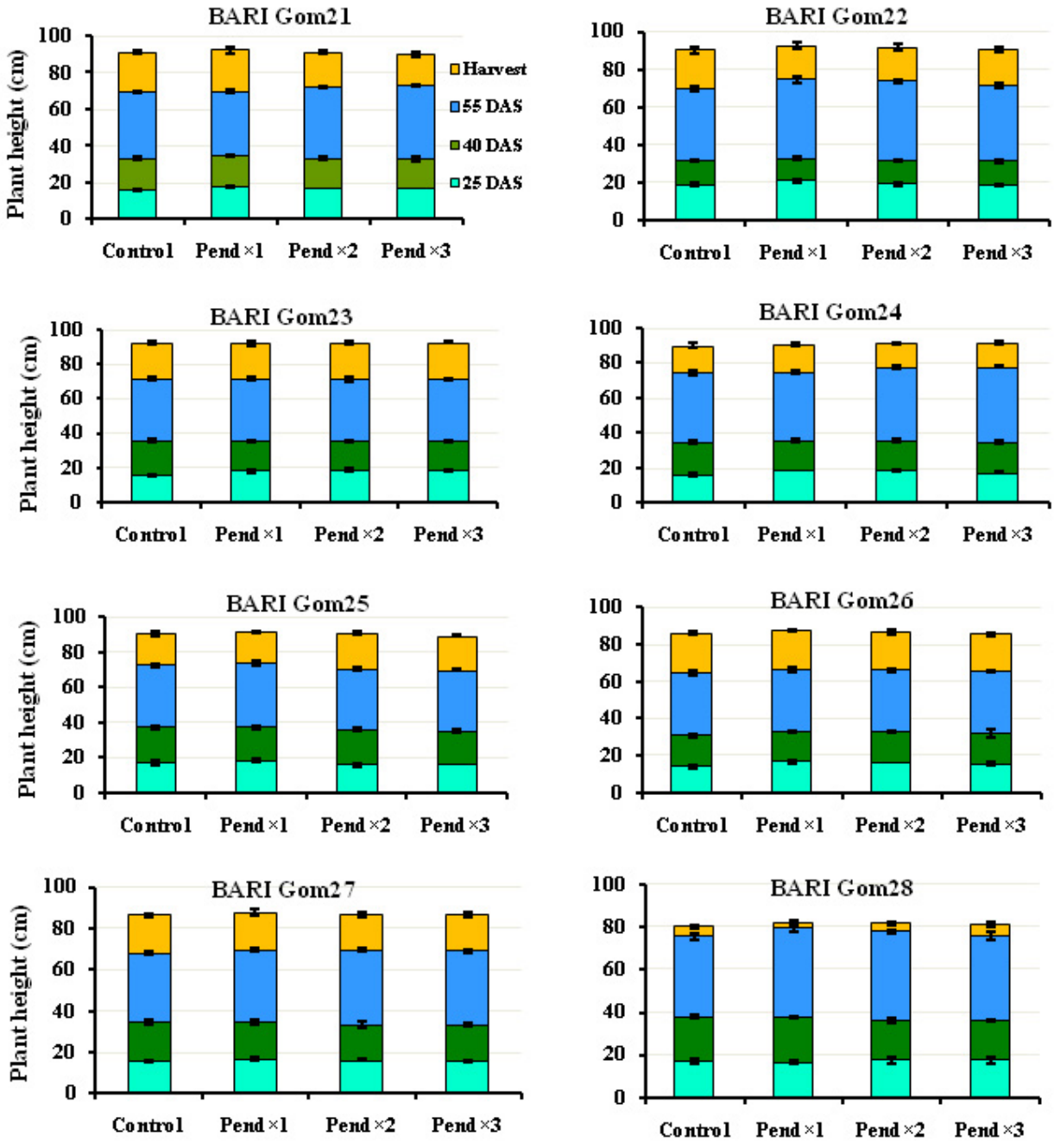

Figure 1. Effect of variety and rate of pendimethalin on plant height at 25, 40 and 55 days after sowing and at harvest of wheat under strip tillage system during 2013-14

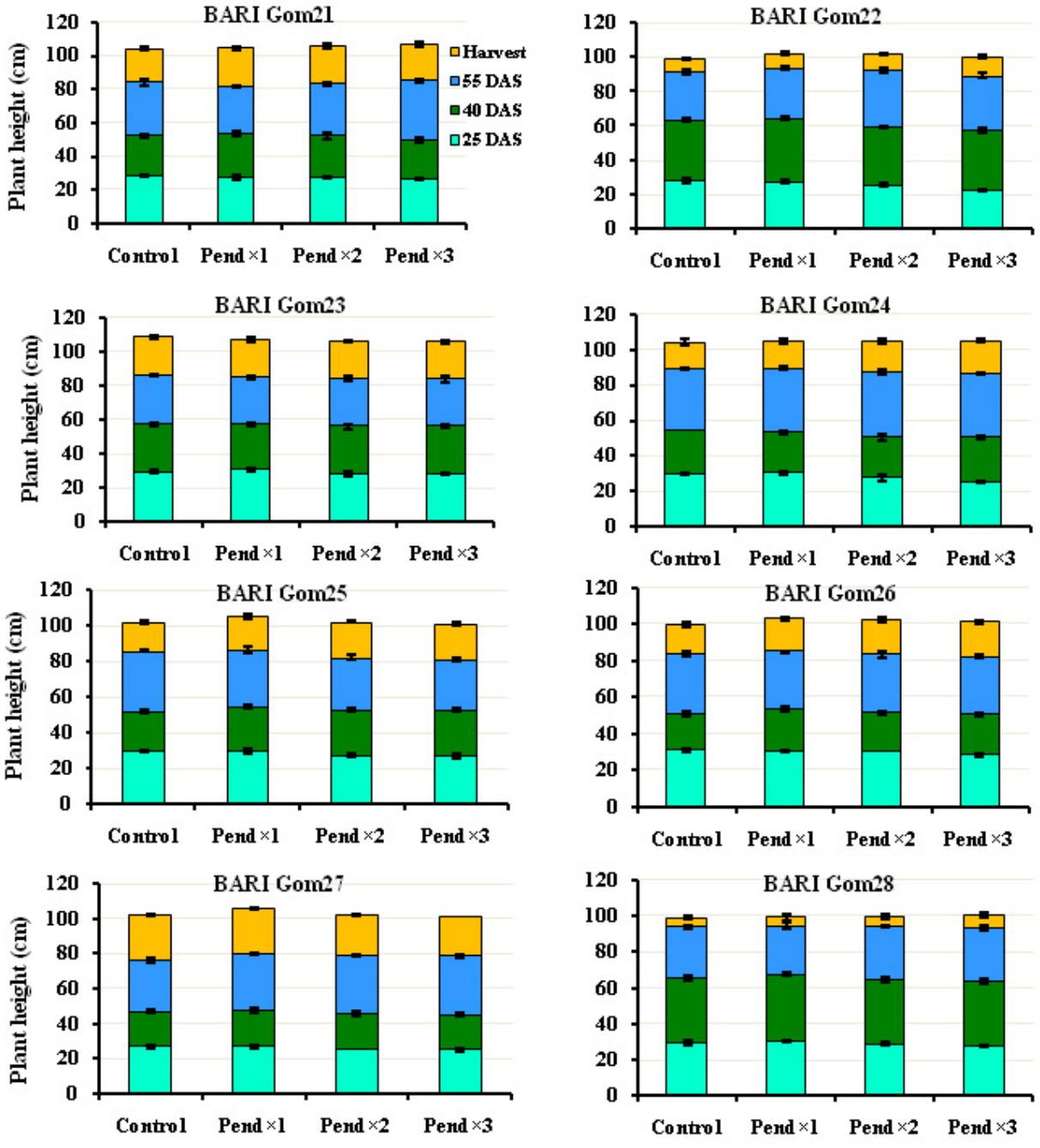

Figure 2. Effect of variety and rate of pendimethalin on plant height at 25, 40 and 55 days after sowing and at harvest of wheat under strip tillage system during 2014-15

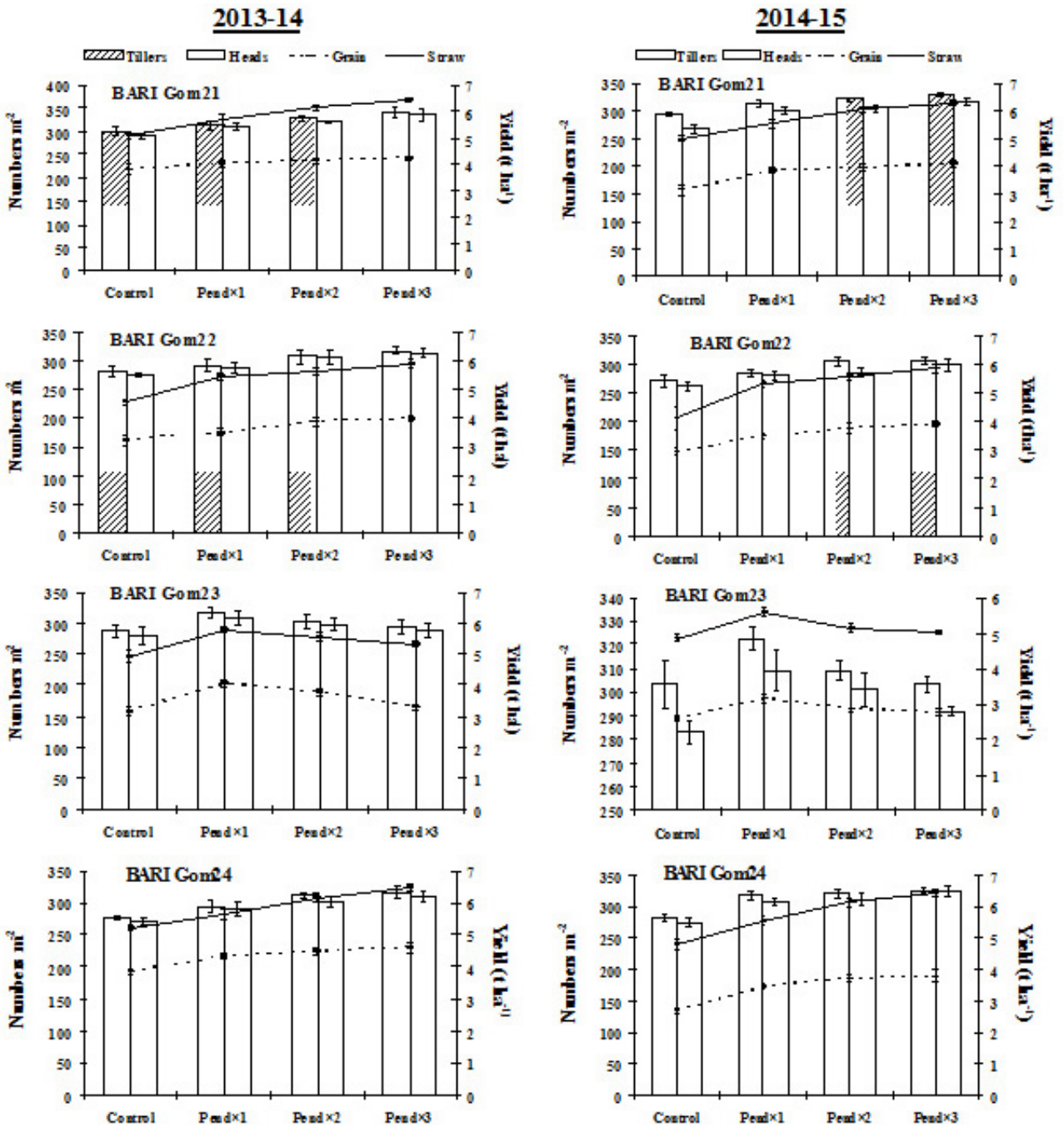

Figure 3. Effect of rate of pendimethalin on numbers of tillers and heads m^{-2}, grain and straw yields of strip-tilled BARI Gom21, BARI Gom22, BARI Gom23 and BARI Gom24 during 2013-14 and 2014-15

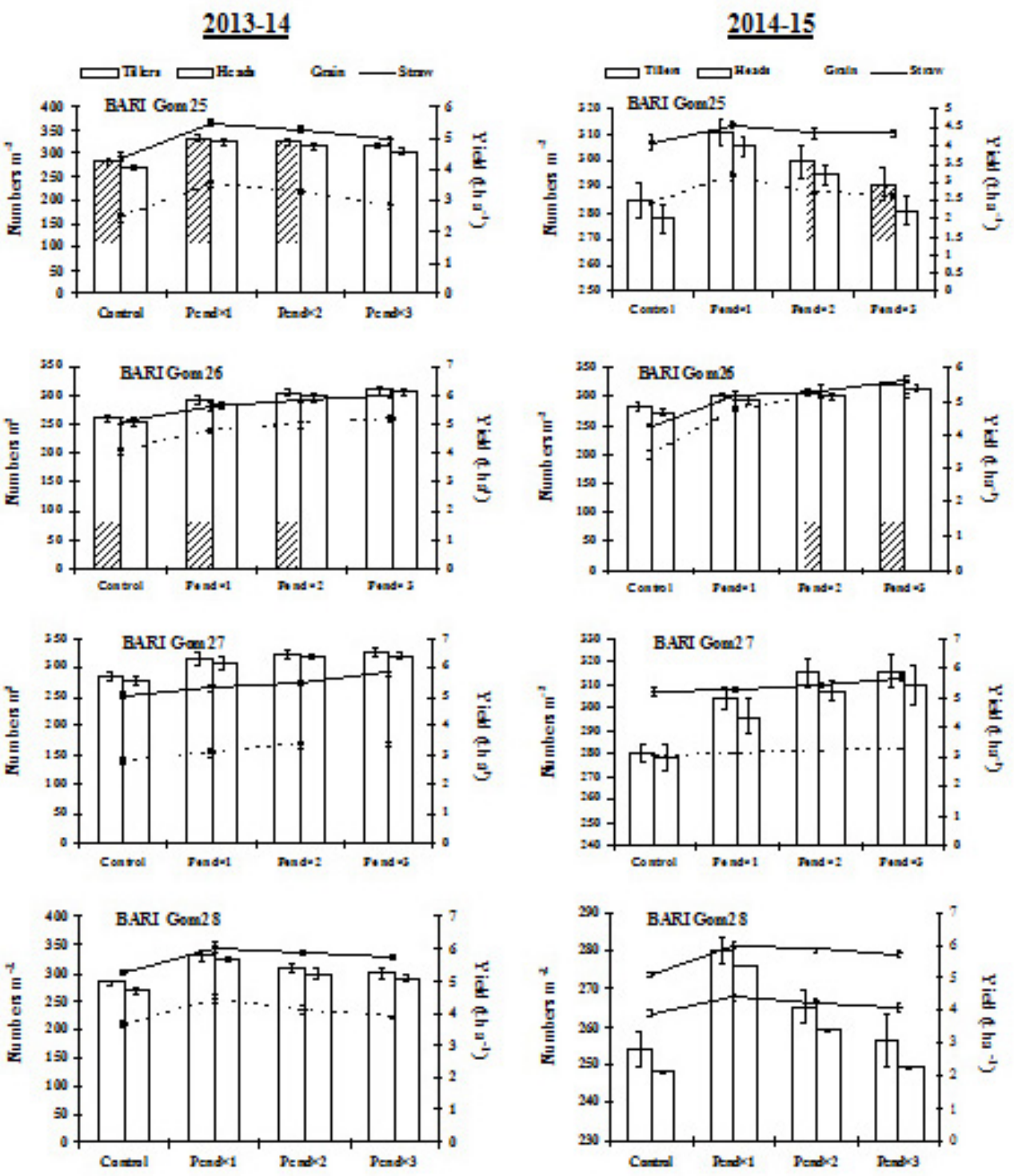

Figure 4. Effect of rate of pendimethalin on numbers of tillers and heads m^{-2}, grain and straw yields of strip-tilled BARI Gom25, BARI Gom26, BARI Gom27 and BARI Gom28 during 2013-14 and 2014-15

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