Research Article

Evaluation of Different Pre and Post Emergence Herbicides for Controlling Weeds in Direct Seeded Rice (*Oryza sativa* L.) in Sargodha Zone Pakistan

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Abstract | Rice is the main crop which fulfills the need of 50% population of the country. In Pakistan rice is cultivated on area of 2.97 million ha with production 7.322 million tons. The production of rice decreased during last year due to high input price and lack of resources at proper time. Certain factors affect the crop yield in which weeds are the most important which compete with crop for nutrients, light and space. For this reason a field experiment was designed to evaluate the efficacy of different pre and post emergence herbicides for control of weeds in Direct seeded rice. Randomized complete block design (RCBD) was used to lay out the experiment at Adaptive Research Farm Sargodha during the summer season of 2022 and 2023. It includes nine treatments (pendimethaline @ 1000 ml/acre, pendimethaline fb bis. sodium + bensulfuran methyl @ 1000 ml and 100 gm/acre, pendimethaline fb bispyrabac sodium + cyhalofop @ 1000 ml and 100gm/acre, pendimethalin fb metmefop @ 1000 and 500 ml/acre, Counsilactive (triefamon+ethoxysulfuron) @ 75 gm/acre, counsilactive fb Bis. sodium + bensulfuran methyl @ 75 and 100 gm/acre, counsilactive fb bispyrabac sodium + cyhalofop @ 75 and 100 gm/acre, Counsilactive fb metmefop @ 75 and 500 ml/acre and weedy check) and three replications. Super Basmati was sown in the 2nd week of June in both Kharif seasons 2022 and 2023 using seed rate 8 kg ac^{-1}. The result revealed that minimum weed infestation was observed in counsilactive fb bispyrabac sodium + cyhalofop butyl + fenoxaprop-P-ethyl (pomextra 16 OD) was 14.33 m-2 followed by pendimethaline fb bispyrabac sodium + bensulfuran methyl (winsta 30WDG) and maximum yield obtain from counsilactive fb bispyrabac sodium + bensulfuran methyl (winsta 30WDG) was 3798.56 followed by pendimethaline fb bispyrabac sodium + bensulfuran methyl (winsta 30WDG) in kharif 2022. While in kharif 2023 the maximum yield obtains from (counsilactive fb bispyrabac sodium + cyhalofop butyl + fenoxaprop-P-ethyl (pomextra 16 OD) were 3269.22 followed by counsilactive fb bispyrabac sodium + bensulfuran methyl (winsta 30WDG). The lowest statistically significant yield was harvest in the weedy check. Hence, applications of pre-emergence herbicide counsilactive and post emergence herbicide winsta 30WDG are recommended to achieve bumper harvests of rice in the target area.

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Introduction

Rice is the main grain crop among all the cereals after wheat, which fulfills the nutritional requirements of more than 50% of the planet population (Kumar and Ladha, 2011). Rice holds significant economic value as a cash crop, following wheat. Its production is composed 34% fine or basmati types and 66% coarse types. Rice contributes approximately in the agricultural sector to the country's GDP. Rice is cultivated on an area of 167mha world widely with estimated yield 782 million tons with average productivity of 4.67 tons ha-1 (FAOSTAT, 2022). Asia is the largest contributor in rice production which is almost 90% of whole production in the world (FAO, 2022).

In Pakistan rice is the 2nd main exportable product after cotton, which added 1.9% in agriculture and 0.4% in GDP. In 2022-23 rice was cultivated on 2976 thousand ha with production 7.322 million tons in which major contribution comes from the Punjab which is almost 69% of the total area under rice and almost 58% of the total production under rice. Rice crop is registered negatively production from last year 2021 which is almost 21.5% (GOP, 2022). The main reason of decline in production was high input prices and lack of resources. During last few years the area of coarse types increased due to hybrid coarse types.

In this area conventional method of paddy cultivation was used in which puddled soil with continue standing water conditions (Singh *et al*., 2006). Due to shortage of water resources the puddled soil become hard after drying which results in cracks and hard pan which adversely affect the production. Puddling also disturbs the physical soil condition which affects the post rice crop (Kalita *et al*., 2020). Besides all these factors the major area of the country has sown by traditional method of transplanting which leads to the less plant population and non-availability of labor on time effect the yield crop.

The main factor and expansion in production technology in rice have augmented the desirability in Direct Seeding method (Subbaiah, 2008). By adopting direct seed Rice (DSR) method, research shows that it is cost-effective in rice establishment method and save the 12-35% irrigation water and up to 60% labor with almost similar or somewhat low yield can be obtained (Kumar and Ladha, 2011).

Despite of many advantages of dry DSR, weeds remain major problem in it. Due to simultaneous appearance of competitive weeds are the main biological limitations in DSR due to absence of water to suppress weeds at the time of seedling appearance (Raj and Syriac, 2017). The risk of yield losses Up to 50% reported from weeds in DSR which is more than the transplanted rice as high as 50-91% (Hossain *et al*., 2016). Mostly hand weeding is adopted in different countries because it is very easy and ecofriendly. With the increase of labor cost and labor shortage are valedictory away from manual weeding which leads the farmers substitute of manual weeding (Ali *et al*., 2019).

In various agro-ecological regions of Pakistan, diverse strategies for weed management are implemented to address the challenges posed by weeds and enhance crop productivity and profitability (Khaliq *et al*., 2013; Siddiqi *et al*., 2014). For better production of crop efficient use of herbicides application is essential in DSR (Azmi *et al*., 2005). Weeds compete with the main crop for resources applied (water, Fertilizer, micronutrients, etc.), therefore timely management of weeds is key to increase the crop production in dry seeded rice (Shekhawat *et al*., 2020). There fore different experiment has been conducted to find out the efficacy of different herbicides for weed control in direct seeded rice in different climatic condition. This is why, the current research was designed to demonstrate and evaluate the efficacy of different pre and post emergence herbicides to control the weeds in directed seeded rice in Sargodha, Punjab region.

Materials and Methods

The field experiment to evaluate the efficacy of different pre and post emergence herbicides for control of weeds in Direct seeded rice was conducted at Adaptive Research Farm Sargodha during the summer season of 2022 and 2023. Randomized complete block design (RCBD) was used to lay out the experiment with three replications. Nine treatments were used in experiment as given in Table 1.

Preparation of land was done by using cultivator 2 time followed by rotavator 2 time after the roni in both seasons. Super Basmati was sown in the 2nd week of June in both seasons using hand drill to maintain the plant to plant and row to row distance 9 inches. The seed rate for super basmati was 8 kg per acre. Seed treatment was done using topsin M @ 2.5gram kg^{-1} of seed. Same fertilizers were applied in both season i.e. 55-35-25 kg NPK per acre. Full dose of Phosphorus, potassium and half dose of Nitrogen were applied at the time of sowing while other remaining nitrogen were applied in two splits one after 30 to 35 after sowing and second application was done after 60 of sowing in both the seasons. While application of 10 kg per acre ZnSO4 (21%) was done after 30-35 days after sowing along with nitrogen fertilizer. While all the other agronomic factors remained same for the crop in both season for Kharif 2021 and Kharif 2022 except the treatments under study.

At maturity total number of tillers, productive tillers and number of panicles m^{-2} were recorded from each experimental unit. After that 10 plants were randomly selected to measure the panicle length by using a scale (meter rod) and number of grains per panicle were also counted and averaged. Rice plant samples from each plot were weighed after threshing to record the straw yield and paddy yield by weighing of grains. Random sampling of 1000 grains was done and weighed.

Weed count was calculated for each treatment separately before and after 15 and 30 days of application. The collected data were analyzed by using the analysis of variance technique with the help of Statistic 8.1 statistical software and the treatment's means were compared by using least significance difference test (LSD) at 5% level of probability (Montogomery, 2013).

Results

Weed Count

Data regarding to weed Count m^{-2} before and after 15 and 30 days of spray are affected by different herbicides are shown in the Figure 1 and Figure 2 for Kharif 2022 and kharif 2023 respectively.

Table 1: *Treatments of the experiment.*

Treatments	Chemical Name	Dose per acre	Time of Application
T1	Pendimethaline	1000 gm	Pre emergence
T2	Pendimethaline fb Bispyrabac sodium + bensulfuran methyl (Winsta 30WDG)	1000 gm and 100 gram	Pre and post at 18-22 DAS
T3	Pendimethaline fb Bispyrabac sodium + Cyhalofop butyl + Fenoxaprop-P-ethyl (Pomextra 16 OD)	1000 gm and 100 gm	Pre and post at 18-22 DAS
T4	Pendimethaline fb Metmefop (green sun)	1000 and 500 ml	Pre and post at 18-22 DAS
T5	Counsilactive	75 gm	Pre emergence
T6	Counsilactive fb Bispyrabac sodium + bensulfuran methyl (Winsta 30WDG)	75 and 100 gm	Pre and post at 18-22 DAS
T7	Counsilactive fb Bispyrabac sodium + Cyhalofop butyl + Fenoxaprop-P-ethyl (Pomextra 16 OD)	75 and 100 gm	Pre and post at 18-22 DAS
T8	Counsilactive fb Metmefop(green sun)	75 and 500ml	Pre and post at 18-22 DAS
T9	Weedy check		

Crop was sown in wattar condition and pre-emergence herbicides was applied within 24 hours of sowing and other post emergence herbicides was applied after germination of weeds in wattar condition at 18-22 DAS.

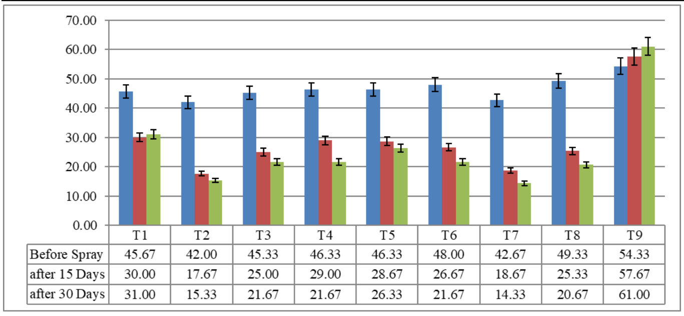

Figure 1: *Weed count before spray, after 15 and 30 day of spray in Kharif 2022.*

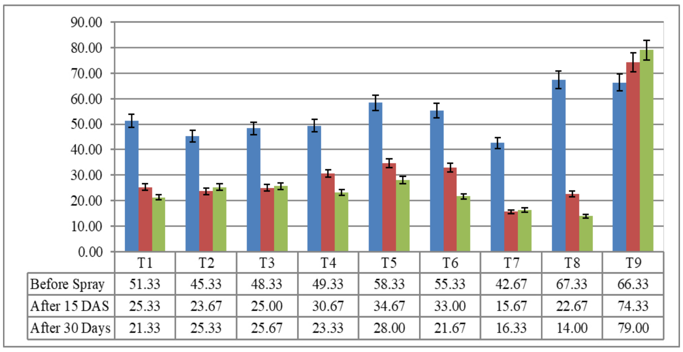

Figure 2: *Weed count m^{-2} before spray, after 15 and 30 days of Spray in kharif 2023.*

The ANOVA shows that weed count before and after 15 and 30 days of spray in khairf 2022 were significantly different statistically. The data in the Figure 1 reveal that minimum weed count before spray observed in T2 (pendimethaline fb bispyrabac sodium + bensulfuran methyl (winsta 30WDG) were 42.00 m^{-2} followed by T7 (counsilactive fb bispyrabac sodium + cyhalofop butyl + fenoxaprop-P-ethyl (pomextra 16 OD) were 42. 67 m^{-2} and 45.33 m^{-2} in T3 (pendimethaline fb bispyrabac sodium + cyhalofop butyl + fenoxaprop-P-ethyl (pomextra 16 OD) respectively. While after 15 days of spay the minimum weed count were observed in T2 were 17.67 m^{-2} followed by T7 were 18.67 m^{-2} and 25.00 m^{-2} in T3 respectively. While after 30 days of spray the minimum weed counts were observed in T7 were 14.33 m^{-2} followed by T2 were 15.33 m^{-2} and 20.67 in T8 respectively.

The ANOVA shows that weed count before and after spray in khairf 2023 were significantly different statistically. The data in the Figure 2 reveal that minimum weed count before spray observed in T7 (counsilactive fb bispyrabac sodium + cyhalofop butyl + fenoxaprop-P-ethyl (pomextra 16 OD) were 42.67 m^{-2} followed by T2 (pendimethaline fb bispyrabac sodium + bensulfuran methyl (winsta 30WDG) were 45.33 m^{-2}and 48.33 m^{-2} in T3 (pendimethaline fb bispyrabac sodium + cyhalofop butyl + fenoxaprop-P-ethyl (pomextra 16 OD) respectively. While after 15 days of spay the minimum weed count were observed in T7 were 15.67 followed by T8 were 22.67 m^{-2} and 23.67 m^{-2} in T2 respectively. While after 30 days of spray the minimum weed counts were observed in T8 were 14.00 m^{-2} followed by T7 were 16.33 m^{-2} and 21.33 m^{-2} in T1 respectively.

Productive tiller

The ANOVA shows that productive tillers in khairf 2022 and 2023 were significantly different statistically. The data in the Figure 3 reveal that maximum productive tillers observed in T7 (counsilactive fb bispyrabac sodium + cyhalofop butyl + fenoxaprop-P-ethyl (pomextra 16 OD) were 289.67 m^{-2} followed by T6 were 267.00 m^{-2} and 240.67 m^{-2} in T8 respectively in kharif 2022. While in kharif 2023 the maximum productive tillers observed in T7 (counsilactive fb bispyrabac sodium + cyhalofop butyl + fenoxaprop-P-ethyl (pomextra 16 OD) were 277 m^{-2} followed by T8 were 268.33 m^{-2}and 251.67 m^{-2} in T6 respectively.

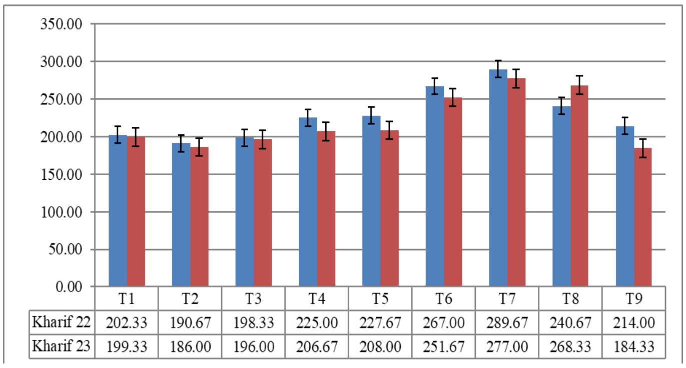

Figure 3: *Productive tiller m^{-2}in kharif 2022 and kharif 2023.*

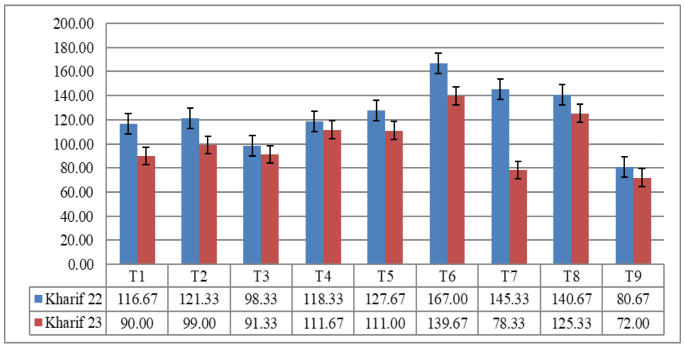

Figure 4: *Grains per Panicle in Kharif 2022 and Kharif 2023.*

Grains per Panicle

The ANOVA shows that productive tillers in khairf 2022 and 2023 were significantly different statistically. The data in the Figure 4 reveal that maximum productive tillers observed in T7 (counsilactive fb bispyrabac sodium + cyhalofop butyl + fenoxaprop-P-ethyl (pomextra 16 OD) were 289.67 followed by T6 were 267 and 240.67 in T8 respectively in kharif 2022. While in kharif 2023 the maximum productive tillers observed in T7 (counsilactive fb bispyrabac sodium + cyhalofop butyl + fenoxaprop-P-ethyl (pomextra 16 OD) were 277. 00 followed by T8 were 268.33 and 251.67 in T6 respectively.

1000 Grain Weight

The ANOVA shows that 1000 grain weight in khairf 2022 and 2023 were significantly different statistically. The data in the Figure 5 reveal that maximum 1000 grain weight observed in T2 were 22.67 followed by T3 was 22.33 and 21.33 in T7 respectively in kharif 2022. While in kharif 2023 the maximum 1000 grain weight observed in T7 (counsilactive fb bispyrabac sodium + cyhalofop butyl + fenoxaprop-P-ethyl (pomextra 16 OD) and T3 were 22.00 followed by T2 were 21.33 and 20.67 in T1 respectively.

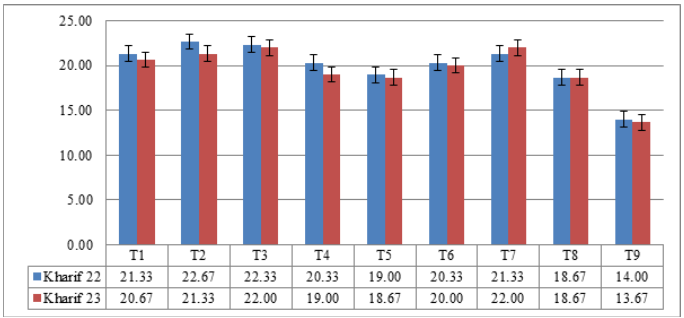

Figure 5: *1000 Grain Weight in Kharif 2022 and Kharif 2023.*

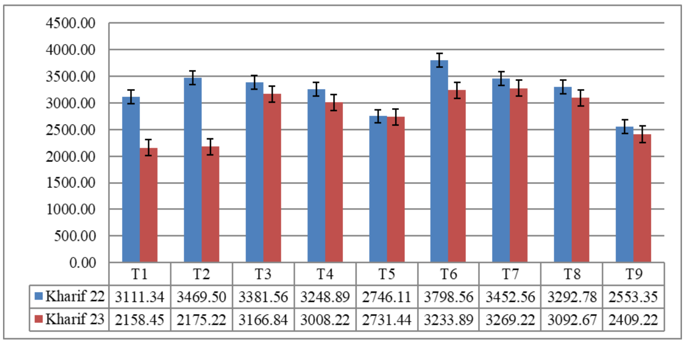

Figure 6: *Yield kg/ha in Kharif 2022 and Kharif 2023*

Yield kg ha^{-1}

The ANOVA shows that yield in khairf 2022 and 2023 were significantly different statistically. The data in the Figure 6 reveal that maximum grain yield observed in T6 were 3798.56 followed by T2 was 3469.50 and 3452.56 in T7 respectively in kharif 2022. While in kharif 2023 the maximum grain yield observed in T7 (counsilactive fb bispyrabac sodium + cyhalofop butyl + fenoxaprop-P-ethyl (pomextra 16 OD) were 3269.22 followed by T6 was 3233.89 and 3166.84 in T3 respectively.

The correlation graph shows that the weed count before spray has positive co relation with weed count after 15 and 30 days of spray and negative correlation with productive tillers, grins per panicle, 1000 grain weight and yield in both seasons Kharif 2022 and Kharif 2023. Similarly, correlation for weeds count after 15 and 30 days of sprays shows directly relation with weed count before spray and inversely relation with productive tillers, grins per panicle, 1000 grain weight and yield in kharif 2022 and kharif 2023. While productive tillers show directly positive relation with Grains per panicle, thousand grains weight and yield.

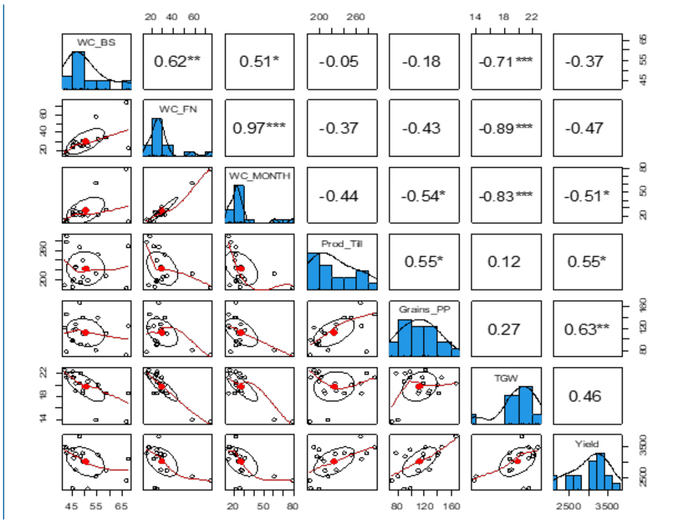

Figure 7: *Correlation matrix among different parameters in Kharif 2022 and Kharif 2023.*

Similarly, the Grains per panicle show directly positive relation with productive tillers, thousand grains weight and yield and negative correlation with weeds count before and after 15 and 30 days of sprays. The correlation graph of thousand grain weight shows directly positive relation with productive tillers, grains per panicle and yield and negative correlation with weeds count before and after 15 and 30 days of sprays.

Economic Analysis

The economic analysis is given in Table 2 which presents total crop yield, gross income, and cost of herbicides application under each treatment.

Discussion

The findings of our study are widely corroborated by the previous work that the use of herbicides at proper

Table 2: *Economics analysis of the experiment.*

	Weeds control Treatments									
Variable	T1	T2	T3	T4	T5	T6	T7	T8	T9	Remarks/ Details
Cost of herbicides	5681	8027	11856	13585	6372	8768	12547	14276	0	Total cost of herbicides Rs ha^{-1}
Spray application cost	1500	1500	1500	1500	1500	1500	1500	1500	0	Rs. 1500/ man, one day ha^{-1}
Total cost of herbicides application	7181	9527	13356	15085	7872	10268	14047	15776	0	Rs ha^{-1}
Total yield	2634	2822	3273	3128	2738	3515	3360	3192	2481	Average yield of both years kg ha^{-1}
Gross income	276570	296310	343665	328440	287490	369075	352800	335160	260505	@ Rs. 105 kg^{-1}

Source: *Authors own calculations.*

time boosts the grain yield due to increase in productive tillers, grains per panicle and grain weight Malik *et al*. (1998) and Madafiglio *et al*. (2006). Similar results were demonstrated by Naik *et al*. (2018) and Menon *et al*. (2016) that application of herbicides at proper time suppresses the weeds and enhances the production of crop.

Previously, it was reported that application of bispyribac sodium at 25-30 g a.i. ha^{-1} could be an appropriate herbicide usage for effective control of diverse rice weed flora under different systems Martin *et al*., 2020). According to Maheswari *et al*. (2015), employing orthosulfamuron at a dose of 120 g ha^{-1} through a pre-emergence sand mix application (SMA) 3- 5 days after transplanting (DAT), followed by a subsequent post-emergence application of orthosulfamuron at the same rate at, emerged as a proficient and cost-effective strategy for weed management in transplanted rice.

This experiment also revealed the work done by Saito *et al*. (2010) and Mennan *et al*. (2012) that the application of inputs at the proper growth time of the crop will help the plants to uptake the optimum nutrients at vegetative growth and help the plants to compete with weeds. Weeds plants compete with main crops for different growth element like space, moisture, light and nutrition which effect the plant growth. This study also revealed that plant height play important role to suppress the weeds population and enhance the number of productive tillers of the crops, as ability of weeds reduce to compete in the presence of taller height plant.

Similar results were described by Deepthi *et al*. (2010) that high population of weeds and a smaller number of productive tillers results in reduction of paddy yield in all the treatments.

Conclusions and Recommendations

The present study concludes that all herbicide application treatments prominently suppressed the weed growth and improved the yield and yield traits of rice planted under DSR system as compared to weedy check. Therefore, a mixed of the above studied pre and post emergence herbicides is recommended in order to effectively control the weed population and growth of grasses and sedges and to get highest net benefits under DSR technology.

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Novelty Statement

This study is the first of its kind in Sargodha region of Punjab Pakistan to evaluate the pre and post Emergence Herbicides for Controlling Weeds in Direct Seeded Rice in Sargodha Zone, Pakistan. The finding not only highlights the significant importance of economical weeds management but also emphasize the best time to control of weeds in Direct Seeded Rice

Author's Contribution

Ali Raza, Muhammad Nawaz, Muhammad Ishfaq and Ishtiaq Hassan: Conceptualization the study

Ali Raza and Ammara Khan: Performed Methodology and investigation
Ali Raza, Muhammad Tanveer Ahmed and Muhammad Arif: Wrote original first draft
Muhammad Arif, Muhammad Tanveer Ahmed, Muhammad Ishafq and Ishtaiq Hassan: Reviewed, edited and finalize the manuscript.

Conflict of interest
The authors have declared no conflict of interest.

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