Research Article

Effect of Different Organic Mulches and Nitrogen Sources on the Productivity of Wheat Crop Grown in Semi-Arid Area

Muhammad Usman Aslam[1], Muhammad Umer Chattha[1], Imran Khan[1], Rizwan Maqbool[1], Muhammad Bilal Chattha[2]*, Fiaz Hussan[3], Muhammad Nawaz[4], Muhammad Shakeel Hanif[5], Muhammad Ahsin Ayub[6], Muhammad Talha Aslam[1], Mina Khan[7] and Muhammad Umair Hassan[1]

[1]Department of Agronomy, University of Agriculture, Faisalabad, 38040, Pakistan; [2]Institute of Agricultural Sciences, University of the Punjab, Lahore, Pakistan; [3]Directorate of Agronomy, Ayub Agricultural Research Institute, Faisalabad, Pakistan; [4]Department of Agricultural Engineering, Khwaja Fareed University of Engineering and Information Technology, Rahim Yar Khan 64200, Pakistan; [5]Fodder Research Institute Sargodha, Pakistan; [6]Rice Research Station, Bahawalnagar, 62031, Pakistan; [7]Department of Management Sciences, National Textile University, Faisalabad, Pakistan.

Abstract | Organic mulches as a soil cover effectively improved soil quality and crop yield. Likewise, application of right nitrogen (N) source also plays an imperative role to increase the crop production and decrease N losses. Therefore, this investigation was aimed at to determine the effect of various N sources and organic mulches on productivity of wheat grown in semi-arid area. The experiment was comprised of different organic mulches, i.e. M_1 = no mulch (control), M_2 = maize straw mulch (5 t ha^{-1}), M_3 = wheat straw mulch (5 t ha^{-1}), M_4 = sorghum straw mulch (5 t ha^{-1}) and nitrogen sources i.e., NS_1 = urea, NS_2 = ammonium sulfate (AS) and NS_3 = calcium ammonium nitrate (CAN). The application of sorghum straw mulch significantly reduced weed biomass compared to other mulch. Moreover, sorghum straw mulch also resulted in maximum leaf area index (LAI), crop growth rate (CGR), productive tillers (323.11), spikelet/spike (15.88), grains/spike (44.55), 1000-grain weight (42.13g), grain yield (5.13 t ha^{-1}) and biological yield (14.59 t ha^{-1}) and minimum, LAI, CGR and tillers (291.55), spikelet/spike (12.55), grains/spike (36.11), 1000-grain weight (35.91g), grain yield (3.67 t ha^{-1}) and biological yield (11.80 t ha^{-1}) was noticed in control (no mulch) . In case of nitrogen sources maximum LAI, CGR and productive tillers (316.91), spikelet/spike (14.91), grains/spike (42.25), 1000-grain weight (41.15g), grain yield (4.60 t ha^{-1}) and biological yield (13.72 t ha^{-1}) was recorded with application of CAN and minimum LAI, CGR and tillers (306.00), spikelet/spike (13.83), grains/spike (38.83), 1000-grain weight (36.83g), grain yield (4.28 t ha^{-1}) and biological yield (12.59 t ha^{-1}) was recorded in urea. Therefore, these results suggested that sorghum straw mulch and N in the form of calcium ammonium nitrate can effectively improve the wheat production in semi-arid areas.

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***Correspondence** | Muhammad Bilal Chattha, Institute of Agricultural Sciences, University of the Punjab, Lahore, Pakistan; Email: bilal1409@yahoo.com
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Keywords | Mulches, Nitrogen, Weeds, Wheat, Productivity

Links Researchers

Introduction

Wheat is the most commonly cultivated and the world's largest crop. It is staple food of Pakistan and during the 2019-20 wheat was grown on 8825 thousand acres and production remained at 24.94 million tonnes (GoP, 2020). Wheat is an important source of calories, proteins, minerals and carbohydrates for human being (Chattha *et al*., 2017a, b, 2018; Hassan *et al*., 2019a, 2021). However, many issues including inappropriate fertilizers, lack of irrigation water, un-availability of certified seeds, prolonged drought and heat stress and weeds infestation are continuously decreasing production of wheat and other crops across the globe (Zain *et al*., 2017; Hassan *et al*., 2020a, b; Muhsin *et al*., 2021). The major reason for the substantial reduction in wheat production is the use of inappropriate fertilizers. Nitrogen (N) is an important element for the growth and establishment of the crop, protein synthesis, and production of carbohydrates (Aslam *et al*., 2015; Chattha *et al*., 2017c). Nitrogen is also responsible for the photosynthesis process in the plants and linked to the production of the amino acid in plants (Shehzad *et al*., 2012). Deficiency of nitrogen in plants causes a significant loss in final production (Mohsin *et al*., 2012). Fertilizer source play a crucial role in availability of nutrients and subsequent crop production. Nitrogen applied in ammonium form substantially increased the wheat growth and yield as compared to N application in nitrate form (Tariq *et al*., 2011).

Water scarcity is another threat that substantially reduced the wheat yield (Chakraborty *et al*., 2008). It is necessary to enhance wheat yielding capacity in semi-arid condition to cope food security challenges. For this, appropriate managerial practices could be adopted to conserve moisture and improve water use efficiency of the crop to get promising results in semi arid environmental regions. Wheat production can be significantly increased with introducing mulches in wheat crop (Rahman *et al*., 2005). Moreover, it is economical and beneficial for water conservation (Chakraborty *et al*., 2008). Straw mulch is a by-product of cereals which can improve various soil properties and crop production (Kosterna, 2014; Nicholson *et al*., 2014; Tan *et al*., 2016).

However, usual practice of farmers about crop residues is to burn them in field which has serious environmental constraints (Maneepitak *et al*., 2019). Moreover, various health issues are also associated with in situ burning. In addition; soil health, OM contents and microbial concentration along with soil mineral percentage are also affected by indiscriminate burning of crop residues (Raza *et al*., 2019). Organic crop management is one of the hygienic crop production options towards sustainable agriculture (Raza *et al*., 2019). Crop production can be increased with use of straw mulch (Gan *et al*., 2013). Introducing various organic mulches improved soil porosity and water use efficiency and reduced the evaporation losses and weeds infestation (Qin *et al*., 2013). Thus, we hypothesized that organic mulches and N sources can vary in their response in terms of growth and yield. Limited studies were done to evaluate the combined effect of different organic mulches and nitrogen sources on wheat productivity under semi-arid condition of Pakistan. Therefore, this study was done to determine the influence of organic mulches and N sources on weeds biomass, wheat growth and yield under semi-arid area.

Materials and Methods

Experimental site

The present study was performed during 2018-19 at student research area, student research area, University of Agriculture Faisalabad (UAF), Pakistan. The study site belongs to semi-arid area with hot and humid climate during summer and dry conditions during winter (Hassan *et al*., 2019b, 2020c) and further climatic conditions during growing period are given in Table 1. The soil sample taken from diverse parts of field ware subjected to determine the different soil properties by following methods of Homer and Pratt (1961). The soil has sandy loam texture with pH 7.7, EC 1.93 dS m^{-1}, available nitrogen 0.0154 %, and total phosphorus and potassium 4.12 and 168 mg kg^{-1}.

Experimental detail

The study was performed in RCBD with split plot arrangement comprising three replications. The study was comprised of four different organic mulch treatments: M_1 = No mulch (control), M_2 = maize straw mulch (5 t ha^{-1}), M_3 = wheat straw mulch (5 t ha^{-1}), M_4 = sorghum straw mulch (5 t ha^{-1}) along with three different nitrogen sources: NS_1 = urea, NS_2 = ammonium sulphate (AS), NS_3 = calcium ammonium nitrate (CAN).

Table 1: *Weather conditions during the crop growing season.*

Months	Monthly average temperature (°C)	Monthly average humidity (%)	Monthly rain fall (mm)
November-19	17.5	74.6	0.6
December-18	14.1	81.7	0.7
Januray-19	13.1	80.7	18
Feburary-19	14.7	79.0	64.2
March-19	19.9	68.5	55.7
April-19	27.8	42.5	31.2

Collection and application of organic mulches

Organic mulches were collected from the student research farm, Department of Agronomy, UAF. The collected organic mulches were choped into 2.5 cm with chopper and applied in field twenty days after sowing (DAS) of wheat crop.

Crop husbandry

The soil was well prepared with ploughing using cultivator (twice) followed by wooden planking for seed bed preparation. The crop was sown with seed drill on 25th November using 125 kg ha^{-1} seed rate, and by maintaining 23 cm row spacing. Single super phosphate (18% P) and sulphate of potash (50% K) was used to apply the full amount of P and K (75:50 kg ha^{-1}) along with half of N fertilizer as a basal dose application. Remaining N was applied in two splits (first with first irrigation and second at booting stage). The crop was irrigated four times during its growing season and other regular agronomic practices were continuously carried out for getting good stand establishment.

Observations

An area of 1 square meter was marked in each plot and all weeds were uprooted and weighed to determine the weeds fresh biomass and later on dried to determine the weeds dry biomass. The crop was harvested from one-foot long row from each plot with the fifteen days interval. Fresh and dry weight of harvested crop was determined through weighing balance. Leaf area was measured through scale method by taking a little fraction of leaves (5 g) from the main lot and leaf area index (LAI) was measured by methods of Watson (1947). Moreover, samples taken for leaf area was oven dried crop growth rate (CGR) was measured by methods of Hunt (1978). Ten plants were chosen and their heights were measured and averaged. Moreover, an area of 1 square meter was marked in each plot and productive tillers were counted. Similarly, 10 spikes from each plot were taken and spike length was measured, spikelets and grains/spikes were counted and averaged. Moreover, a sub-sample of seeds was taken and 1000 grains were counted and weighed. Additionally, whole plots were harvested and threshed to determine both the biological and grain yield whereas harvest index was taken as ratio of grain and biological yields.

Statistical analysis

The data on weeds biomass, growth and yield traits were analyzed by Fisher's ANNOVA technique and difference among the treatments were compared with LSD test at 5% probability level (Steel *et al*., 1997).

Results and Discussion

Organic mulches (OM) had significant impact on weeds fresh and dried biomass. Whereas, the nitrogen sources and interaction of OM and N sources showed non-significant effect on weed related parameters (Table 1). The maximum weeds fresh weight (WFW) (15.70 gm^{-2}) and weed dry weight (WDW) (5.3 gm^{-2}) and lowest WFW (5.97 gm^{-2}) and WDW (1.94 gm^{-2}) were recorded from the plots where sorghum straw mulch (SSM) was applied (Table 1). All types of mulches significantly reduced the WFW and WDW compared to the control. This reduction in weeds biomass under mulch application could be to reduction in weeds germination and reduction in weeds growth due to covering soil surface with mulches (Afridi *et al*., 2014).

The current findings indicated that various OM and N sources had a significant impact on the LAI and CGR (Figures 1, 2). The maximum LAI and CGR was noticed with application of sorghum mulch and lowest was noticed in control, while in case of N sources maximum LAI and CGR was reported with CAN application and lowest was reported with urea application. Initially the difference among the treatments for the LAI and CGR was not significant however, LAI and CGR increased with time and reached to maximum value after 75DAS, afterwards the LAI and CGR started to decline. The maximum decline in LAI and CGR was noticed in control, while minimum reduction in LAI and CGR after 75DAS was recorded in sorghum mulch. Among N sources, maximum reduction in LAI and CGR after 75 DAS was noticed for urea and minimum reduction was noticed for CAN (Figures 1, 2). The application of OM on soil surfaces reduce the loss of water and favors the better water and nutrients movement which helped the plants to produce more leaves which resulted in more LAI. Nitrogen is an important part of plant molecules and its application significantly improved the various physiological processes and resulting in an increase in assimilates production which favored the production of more leaves and consequently leads to more LAI. Likewise, Abayomi and Fagbenja (2005) also found the significant increase in LAI with N application from different sources. The maximum CGR was recorded with sorghum mulching and CAN application. This increase in CGR can be due increase in LAI which helped in better light harvesting to more assimilates production and resulted in significant increase in the CGR. Likewise, Singha *et al.* (2018) also noted appreciable increase in CGR with application of OM. These outcomes are in lines with findings of Olugbemi and Ababyomi (2016) they also found significant increase in the CGR with N application.

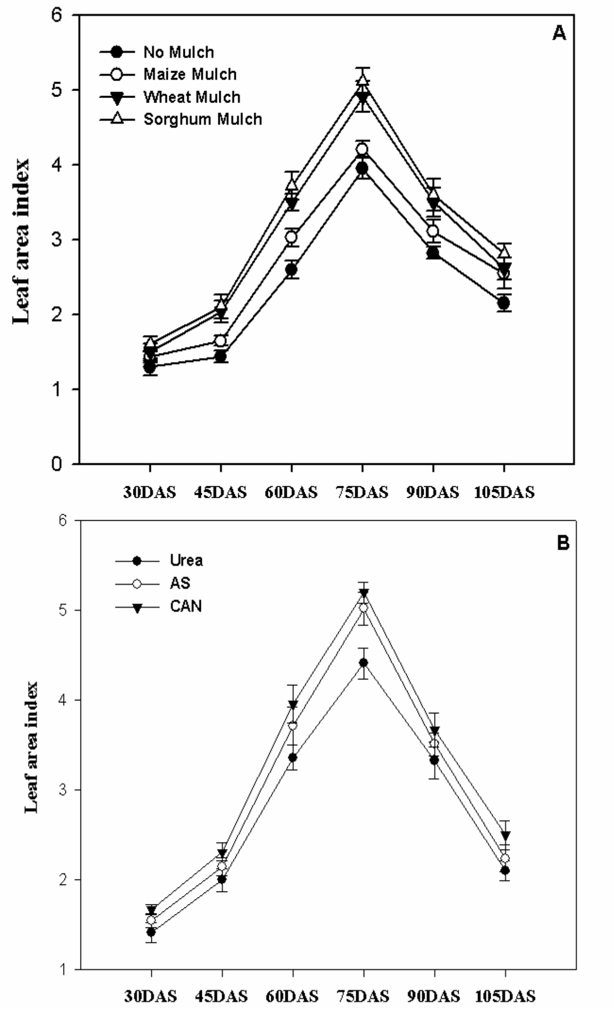

Figure 1: *The effect of organic mulches (A) and nitrogen sources (B) on leaf area index of wheat crop.*

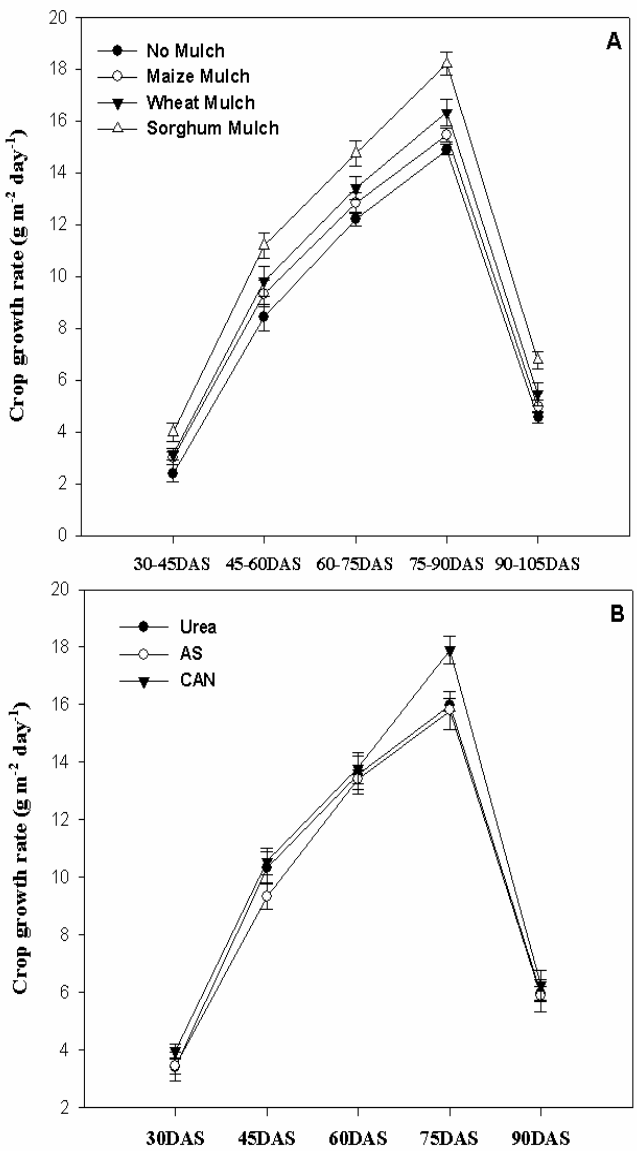

Figure 2: *The effect of organic mulches (A) and nitrogen sources (B) on crop growth rate (g m^{-2} day^{-1}) of wheat crop.*

The maximum plant height (109.11 cm) and spike length (13.76 cm) was obtained with use of SSM while lowest plant height (97.67 cm) and spike length (11.47 cm) was attained in control (no mulch) treatment. The maximum productive tillers (323.11 m^{-2}) were recorded with SSM that was statistically at par with wheat straw mulch (WSM) and lowest productive tillers (291.55 m^{-2}) were recorded in control (Table 2). For nitrogen sources, maximum plant height (106.25 cm) and spike length (13.55 cm) was obtained with CAN over urea application. The highest productive tillers (316.91 m^{-2}) were recorded with CAN that was statistically similar with AS, and lowest productive tillers (306.00 m^{-2}) were recorded with urea application (Table 2). The increase in plant height, productive tillers and spike length can be attributed to maintenance of optimum moisture, weed control and higher LAI and CGR which contributed towards the higher assimilates production therefore resulted in production of taller plants with longer spikes. Likewise, Singh *et al.* (2017) also noted an appreciable increase in growth and yield traits with application of OM. N applied in the form of urea is lost and only 20-50% N applied in the form is urea is absorbed by the plants. Therefore, increase in tillers with CAN and AS can be attributed to better availability of N which in turn improved LAI, assimilate production and thus resulted in production of more tillers compared to urea (Maria-Ramirez *et al.*, 2011).

Organic mulches and nitrogen sources significantly affected the spikelets and grains/spike however, their interaction remained non-significant (Table 3). The maximum spikelets/spike (15.88) and grains/spike (44.55) were recorded in sorghum straw mulch while the minimum grains/spike (36.11) and spikelets/spike (12.55) were noted in control (Table 3). In nitrogen sources maximum grains/spike (14.91), spikelets/spike (42.25) was obtained with CAN and lowest spikelets/spike (13.83) was recorded in urea that was statistically similar (14.08) with AS (Table 3). Production of more spikelets/spike due to mulch application can be due to better water conservation which is essential for the different processes including the nutrients transport from soil to roots and translocation of assimilates from source to sink. Previously, Rahman *et al.* (2005) stated that application of sorghum mulch increased the spikelets/spike, compared to control. The source of N fertilizers significantly affects crop production and nutrients availability. Therefore, increase in spikelets/spike, by CAN application can be due superior N availability compared to urea and AS (Jan *et al.*, 2002).

Table 2: *Effect of organic mulches and nitrogen sources on weeds biomass and yield traits of wheat crop.*

Organic mulches (OM)	Weed fresh weight (g)	Weeds dry weight (g)	Plant height (cm)	Productive tillers (m^{-2})	Spike length (cm)
No mulch (NM)	15.70A	5.35A	97.67D	291.55C	11.47C
MSM (5 t ha^{-1})	12.23B	3.98B	100.33C	312.78B	12.93B
WSM (5 t ha^{-1})	8.42C	2.34C	104.78B	318.55AB	13.03B
SSM (5 t ha^{-1})	5.97D	1.94D	109.11A	323.11A	13.76A
LSD≤0.05P	0.45	0.22	2.38	9.54	0.26
Sources of Nitrogen (SON)					
Urea	10.59	3.45	100.24C	306.00B	11.90C
AS	10.61	3.40	102.41B	311.58AB	12.95B
CAN	10.54	3.33	106.25A	316.91A	13.55A
LSD≤0.05P	NS	NS	1.91	7.59	0.19
OM × SON	NS	NS	NS	NS	NS

MSM: maize straw mulch, WSM: wheat straw mulch, SSM: sorghum straw much, AS: Ammonium sulfate, CAN: calcium ammonium nitrate, means with different letters differed at 0.05 P.

Table 3: *Effect of organic mulches and nitrogen sources on yield and yield traits of wheat crop.*

Organic mulches (OM)	Spikelets/spike	Grains/spike	1000 grain weight (g)	Grain yield (t ha^{-1})	Biological yield (t ha-1)	Harvest index (%)
No mulch (NM)	12.55B	36.11D	35.91C	3.67D	11.80D	31.15B
MSM (5 t ha^{-1})	13.67B	39.33C	37.49BC	4.11C	13.11B	31.31B
WSM (5 t ha^{-1})	15.00A	41.00B	39.26B	4.83B	13.20B	36.78A
SSM (5 t ha^{-1})	15.88A	44.55A	42.13A	5.13A	14.59A	35.20A
LSD≤0.05P	1.22	1.08	2.08	0.19	0.57	1.80
Sources of Nitrogen (SON)						
Urea	13.83B	38.83C	36.83B	4.28C	12.59C	34.06A
AS	14.08AB	39.67B	38.11B	4.41B	13.21B	33.35B
CAN	14.91A	42.25A	41.15A	4.60A	13.72A	33.42B
LSD≤0.05P	0.97	1.69	1.34	0.13	0.21	0.18
OM × SON	NS	NS	NS	NS	NS	NS

MSM: maize straw mulch, WSM: wheat straw mulch, SSM: sorghum straw much, AS: Ammonium sulfate, CAN: calcium ammonium nitrate, means with different letters differed at 0.05 P.

The maximum thousand grain weight (42.13 g) and grain yield (5.13 t ha^{-1}) was obtained from SSM compared to control (no mulch) where the minimum thousand grain weight (35.91 g) and grain yield (3.67 t ha^{-1}) was noted in control Table 3. Among nitrogen sources maximum 1000 grain weight, and grain yield was obtained from CAN application (Table 3) and minimum was recorded with urea application. The present increase in yield by sorghum mulch can be due production of more LAI, CGR, tillers, grains/spike, 1000 grain weight all of which contributed towards to more production. Likewise, Zhang *et al.* (2008) also noted significant increase in the grain yield with mulch application. Moreover, the maximum grain yield was recorded with CAN which can be due to higher LAI, CGR, tillers, grains/spike, 1000 GW. These results are in line with outcomes of Khursheed and Maqsuda (2015) they also noticed the significant difference among N sources for the grain yield.

The highest biological yield (14.59 t ha^{-1}) was recorded in SSM after that WSM that was statistically similar with MSM (13.11 t ha^{-1}), while lowest biological yield (11.80 t ha^{-1}) was obtained from control (no mulch) (Table 2). In nitrogen sources, the highest biological yield (13.72 t ha^{-1}) was obtained from CAN after that from lowest biological yield was recorded in urea (Table 3). The application of OM significantly improved the biological yield owing to maintenance of favorable moisture conditions, soil temperature which results in better dry matter accumulation and thus resulting in increase in biological yield (Rahman *et al.*, 2005). Nitrogen application in present study also significantly increased the biological yield however maximum increase was reported with CAN application. This increase can be attributed to better N availability which resulted in significant improvement in biomass yield. Harvest index (HI) was significantly affected with OM and nitrogen (Table 2). The maximum HI (35.20%) was obtained from SSM that was statistically at par with WSM, after that in (MSM which was statistically same with control (Table 2). In N sources, maximum HI (34.06) was recorded with urea application after that with AS and lowest HI was recorded in CAN (Table 3). The OM and N sources significantly affected the HI, however, maximum HI was noticed with application of sorghum mulch and CAN owing to maximum grain and biological yield.

Conclusions and Recommendations

Organic mulches and different sources of nitrogen had substantiated impact on weeds biomass, crop growth and yield traits. However, application of sorghum straw mulch and CAN remained at top with respect to crop growth and final productivity. Therefore, the application of sorghum straw mulch and CAN be promising approach to enhance the wheat productivity in semi-arid areas.

Novelty Statement

Limited information is available related to effect of different organic mulches on nitrogen on the performance of wheat crop grown in semi-arid conditions. Therefore, this study was conducted to evaluate the role different organic mulches and nitrogen sources on the performance of wheat crop.

Author's Contribution

Muhammad Usman Aslam: Conducted the experiment.
Muhammad Umer Chattha: Conceived and planned the experiment and write the original draft.
Imran Khan: Conceived and planned the experiment.
Rizwan Maqbool, Muhammad Bilal Chattha, Fiaz Hussain, Muhammad Nawaz, Muhammad Shakeel Hanif, Muhammad Ahsin Ayub and Mina Kharal: Reviewed and edited.
Muhammad Talha Aslam: Helped in Data collection.
Muhammad Umair Hassan: Wrote the original draft.

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

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