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Effect of Different Organic Fertilizers and NPK on Growth and Yield of Lentil (*Lens culinaris*)

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ABSTRACT

The experiment was conducted during the month of November, 2022-March, 2023 in Agronomy Farm, Department of Agriculture, Far Western University, Tikapur, Kailali, Nepal to evaluate the combine effects of different organic fertilizers and NPK on growth and yield attributes of lentils. The experiment was laid out in a randomized complete block design (RCBD) with four treatments and five replications. The treatments used were: Farm yard manure @ 6 t ha^{-1} (T1), vermicompost @ 1 t ha^{-1} (T2), panchagavya @ 3% solution (T3) and control (T4). The recommended dose of chemical fertilizers (20:20:20 kg NPK ha^{-1}) were used as a basal dose in all the treatments. It was observed that the application of FYM proved to be significantly superior in terms of plant height, branch number, first flat pod observation, number of pods/plant (107.18), number of filled pods/plant (101.30), total biomass/plant (79.0 g), number of seeds/pod (1.87) and grain yield/ha (1558 kg). The effects remain similar and non-significant in terms of parameters like germination percentage and other growth stages i.e., branching, flowering, number of unfilled pods/plant, pod weight/plant, grain weight/plant, 1000 grain weight, stover yield and harvest index. FYM also recorded the highest gross return (Rs. 155,800) and net return (Rs. 103,183.33) with a slightly lower BC ratio (2.96) compared to control (3.12). In conclusion, FYM proved to be the best option for achieving the highest grain yield and overall economic returns while control remained the most economical choice based on the benefit-cost ratio.

Keywords: Farm yard manure, Grain yield, Vermicompost, Gross return, Panchagavya

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INTRODUCTION

Lentils are widely grown in many countries around the world with the total global production of 5.6 million tons in a cultivation area of 5.58 hectares (FAOSTAT 2022) because of their nutritional importance as well as their ability to restore soil fertility. In Nepal, malnutrition is a persistent problem. Many poor people cannot afford high-quality products for taking nutrients, so for the poor and disadvantaged, it is a significant source of protein. Consuming lentils can help manage chronic conditions including diabetes, obesity, and cardiovascular diseases. Overall, widespread consumption and cultivation lead to food and nutritional security and a factor of managing chronic diseases reflects medicinal importance.

Lentils are cool-season crops that are well adapted to semi-arid region with low precipitation. They can grow in moderate temperatures between 10-25°C and require moderate irrigation (Sharma et al 2022). The major lentil-producing districts in Nepal are Dang, Kailali, Rautahat, Bardiya, Siraha, and Bara (MoALD 2020/21). Kailali alone produces 28351 metric tons of lentils with a cultivation area of 21,035 ha (MoALD 2020/21). Due to the capacity of lentils to tolerate drought conditions, their ability to fix atmospheric nitrogen and their important role in breaking the disease cycle, they are considered an important food crop in Nepal's cropping system. In Nepal, farmers adopt different practices for producing lentils. Practices like selecting the right variety, fining and tilthing the soil using a power tiller and manuring the field with organic fertilizers and farm yard manure are usually adopted. Farmers can also use the crop rotation method for the prevention of disease, pests, and weeds.

For the management of nutrient levels, farmers often use a combination of organic fertilizers with a recommended dose of NPK that is tailored specifically to the need of lentils.

On one hand, large amount of crop production can be achieved using the chemical fertilizers but the extensive application of such synthetic chemicals result in serious environmental hazards, deteriorate the soil biological and physiochemical properties as well as decrease the crop yield. On the other hand, different organic fertilizers are widely available in our remote areas at a low price as compared to chemical fertilizers. They are affordable, easily accessible, environmentally benign, and might be used as a source of nutrients for soil and plants. (Sai Pratap et al 2020). However, organic fertilizers are bulky, contain an imbalanced amount of nutrient content and are unable to overcome the nutritional requirement of the broad zone. Due to such limitations, neither organic nor inorganic fertilizers can ensure stable productivity over the years when applied separately (Arif et al 2016). Therefore, the application of organic fertilizers like Farm yard manure, Vermicompost, Panchagavya, etc. along with chemical fertilizers is necessary for sustainable production and maintaining or restoring soil fertility (Guerena et al 2016).

Farmers are still confused regarding use of fertilizers in legumes. This study will assess the growth of interest among the farmers in identifying alternative sources of fertilizers while adopting sustainable agriculture practices for the production of higher yielding and better quality lentil. Thus, this study will provide valuable information to promote sustainable agriculture as we aim to study the effect of different organic fertilizers and NPK on growth and yield of lentil.

MATERIALS AND METHODS

Experimental site

The study was carried out in the Agronomy Farm, Department of Agriculture, Far Western University, Tikapur, Kailali, Nepal from 16th November 2022 to 29th April 2023. Geographically, it is located at an elevation of 161 meters above mean sea level at a latitude of 28°32’26" N and a longitude of 81°7’26" E. The experimental site had sandy soil with a pH value of 8.1. The content of organic matter and nitrogen% were low. Availability of phosphorus was also low, measuring 7.84 kg ha^{-1}. The soil had medium level of potash i.e. 135.6 kg ha^{-1}.

Experimental Setup

The experiment was carried out in a randomized complete block design (RCBD) with four treatments and each treatment was replicated five times. There were altogether 20 individual plots. Each plot in this pattern measured 3 meters long and 2 meters wide, with row-to-row and plant-to-plant spacing of 20 cm and 10 cm, respectively. Every allotment had 14 rows, each having 19 plants. The overall and net experimental plot area were 210 m^2 and 120 m^2 respectively, with inter-replication spacing of one meter and inter-plot spacing of 0.5 meter. Khajura-2 lentil variety was used for the experiment. There were four treatments which are shown in the Table 1.

Table 1. Treatments

S.N.	Notation	Treatment	Quantity/plot
1.	T_1	Farm yard manure (6 ton ha^{-1}) + 100% NPK	3.6 kg
2.	T_2	Vermicompost (1 ton ha^{-1}) +100% NPK	600 g
3.	T_3	Panchagavya (3% solution) +100% NPK	3.2 liter (dilute with water)
4.	T_4	Control (100% NPK)	-

Seed treatment and sowing

The normal seed rate of lentil is 50-60 kg ha^{-1} for broadcasting. But line sowing was preferred in this trial. The Khajura-2 variety of lentil was used for the experiment and the seeds were sourced from Grain Legume Research Center, Khajura, Banke. For that, one kg of lentil seed was soaked in a prepared fungicide solution for 5–10 minutes and then dried in the shade for 45 minutes before sowing. The seed sowing was done on 16th November 2022 in a well-prepared field by the line sowing method at a rate of 2 seeds per hill. The seeds were sown by maintaining 20 cm ×10 cm row-row and plant-plant distance. Then the seeds were covered with fine soil by hand.

Manure and fertilizer application
The recommended dose of organic and chemical fertilizers (MoALD 2022) used for cultivation of lentil was as follows:

a) FYM = 6 t ha^{-1}
b) Urea = 26.47 kg ha^{-1}
c) DAP = 43.48 kg ha^{-1}
d) MOP = 33.33 kg ha^{-1}
e) Vermicompost =1 t ha^{-1}
f) Panchagavya = 3% solution in water

All the FYM, Urea, DAP, and MOP and 75% of required vermicompost was applied during the land preparation. Remaining 25% of vermicompost was provided in the form of vermiwash (vermiwash is the filtered mixture of vermicompost and water). Vermiwash was applied at the rate of 2.5 liter per plot at a time right after performing weeding. Panchagavya was sprayed by preparing 3% solution in water for 3 times viz; first spray at 5th leaf stage (V5 stage), second spray at 7th leaf stage (V7 stage) and third spray at 1st branching stage of lentil.

Cultural practices
Thinning was done 15 days after sowing followed by gap filling and two weeding was done at 3rd and 10th weeks after sowing manually. It was irrigated thrice at 3rd week after planting, flowering and pod filling stage and was harvested on 29th March 2023. After harvesting, the pods of lentil were allowed to dry for 2 days on sunny days and threshed manually with wooden sticks.

Data collection
The data on phenological parameters like germination percentages, plant height, branch number, period of flowering and first flat pod observation were taken during different stages of crops whereas the yield attributes like number of pods/plant, number of filled pods/plant, biomass/plant, no. of seeds/pod, 1000 grain weight, grain yield/ha were taken at the time of harvest. The data were taken from randomly selected 10 plants for all the growth and yield attributes except for grain yield were recorded from one meter square plot. The data collected was tabulated and averaged for each parameter in excel sheet.

Statistical Analysis
Analysis of variance table was prepared for each parameters and treatments were compared using least significant difference test at 5% level of significance using the software R-studio version 4.2.3.

RESULTS AND DISCUSSION

Weather condition
During the experiment period, the maximum temperature (26.25°C) was recorded in March and the minimum temperature (9.45°C) was recorded in December. The total precipitation during the experimental period (i.e. 16th November 2022- 29th March 2023) was 40.54 mm with maximum of 0.8 mm during the month of March. Relative humidity (85.56%) was found to be highest in November and the lowest (32.69%) in March (Stackhouse 2024).

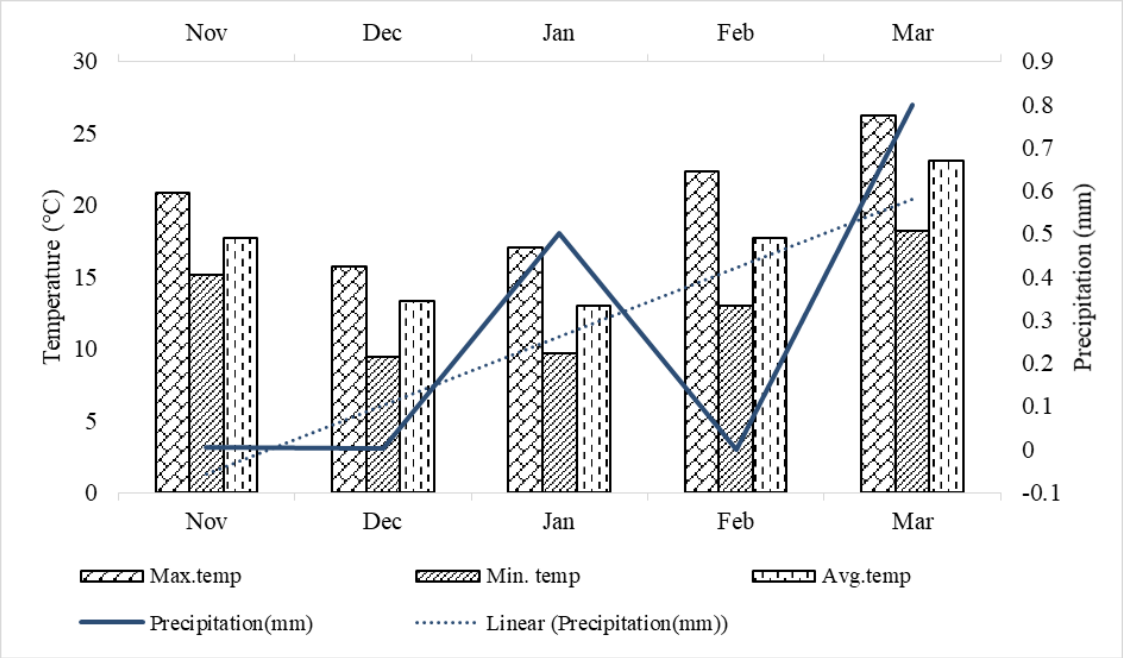

Figure 1. Temperature and precipitation recorded at experimental site during the experimental period, Tikapur, Kailali

Germination %

The combine effect of different organic fertilizers along with chemical fertilizer is shown in table 2. Treatment having FYM, vermicompost, and NPK only had higher germination percentages as compared to the panchagavya (85.75%). Among them, the highest germination% was recorded in FYM (90.36%) followed by vermicompost (89.26 %) and NPK (89.07%). However, there were no significant differences observed among the treatments. The data is given in Table 2.

Table 2. Effect of different organic fertilizers on the germination percentages of lentil

Treatments	Germination % at 15 DAS
FYM + 100% NPK	90.36
Vermicompost + 100% NPK	89.26
Panchagavya + 100% NPK	85.75
Control (100% NPK)	89.07
Grand Mean	88.70
SEm (±)	1.91
LSD(0.05)	5.88
F-test	ns
CV (%)	4.81

Note: SEm: Standard error of mean, LSD: Least significant difference, CV: Coefficient of variation, ns: non-significant, values with the same letters in the columns are not significantly different at 5% LSD (Least significant difference) Test.

Number of branches

As shown in table 3, at 45 DAS, there was no significant difference observed among the treatments. However, branch number was significantly influenced by the application of different organic fertilizers along with NPK at 60 DAS. Treatment having FYM had the highest number of branches per plant (10.20) followed by panchagavya (9.34), and the lowest branch number was found in the treatment having NPK only (8.55). Branch number was also significantly influenced by the application of different organic fertilizers at 80 DAS. The highest number of branches per plant (21.38) was found treatment having FYM followed by vermicompost (20.73 branches) and the lowest number of branches per plant (19.84) was found in the treatment having NPK only. Overall, the data indicates that combined application of FYM and 100% NPK consistently promoted the largest average number of branches per plant at different DAS, with vermicompost and panchagavya showing favorable effects but to a lesser extent. Throughout the experiment, the treatment having NPK only had lower number of branches. These results corroborate with those of Bhuiya et al (2017), Saket et al (2014) and Zeidan (2007). Bhuiya et al (2017) noted highest number of branches of lentil in 20 t ha^{-1} compost. Saket et al (2014) reported that the highest average number of branches (15.89) were obtained from 5 t ha^{-1}.

Table 3. Effect of different organic fertilizers on branch number at different DAS

Treatments	Branches number per plant		
	45 DAS	60 DAS	80 DAS
FYM + 100% NPK	5.91	10.20[a]	21.38[a]
Vermicompost + 100% NPK	5.10	8.69[b]	20.73[ab]
Panchagavya + 100% NPK	5.28	9.34[ab]	20.05[b]
Control (100% NPK)	4.94	8.55[b]	19.84[b]
Grand Mean	5.31	9.20	20.50
SEm (±)	0.31	0.31	0.30
LSD(0.05)	0.95	0.97	0.92
F-test	ns	*	*
CV (%)	12.94	7.63	3.27

Note: SEm: Standard error of mean, LSD: Least significant difference, CV: Coefficient of variation, ns: non-significant, *: Significant at 5% probability level, values with the same letters in the columns are not significantly different at 5% LSD (Least significant difference) Test.

Plant height

At 45 DAS, plant height was significantly influenced by the application of different organic fertilizers along with NPK. The highest plant height (7.99 cm) was recorded in vermicompost treatment which was statistically at par with FYM (7.96 cm) and panchagavya (7.59 cm) whereas the lowest plant height (6.87 cm) was found in control (NPK only). Plant height was significantly increase by 14.02% in vermicompost, 13.69% in FYM and 9.48% in panchagavya over control whereas at 60 DAS, there was no significant differences observed among the treatments at 5% level of significance. At 80 DAS, plant height was also significantly influenced by the application of different organic fertilizers. The highest plant height (16.34 cm) was found in the FYM followed by vermicompost (15.99 cm) and the lowest (15.47 cm) was found in control. The data are given in table 4.

Table 4. Plant height as influenced by different organic fertilizers at different DAS

Treatments	Plant height (cm)		
	45 DAS	60 DAS	80 DAS
FYM + 100% NPK	7.96[a]	10.46	16.34[a]
Vermicompost + 100% NPK	7.99[a]	10.10	15.99[ab]
Panchagavya + 100% NPK	7.59[a]	9.92	15.69[b]
Control (100% NPK)	6.87[b]	9.81	15.47[b]
Grand Mean	7.60	10.07	15.87
SEm (±)	0.23	0.33	0.17
LSD(0.05)	0.70	1.0	0.53
F test	*	ns	*
CV (%)	6.73	7.23	2.44

Note: SEm: Standard error of mean, LSD: Least significant difference, CV: Coefficient of variation, ns: non-significant, *: Significant at 5% probability level, values with the same letters in the columns are not significantly different at 5% LSD (Least significant difference) Test.

According to the findings, applying organic fertilizers along with NPK was found to increase plant height throughout the observed period as compared to the applying NPK alone. FYM consistently produced the tallest plants among the organic treatments at all observation sites. These findings are in agreement with those of Saket et al (2014), Zeidan (2007) and Bhuiya et al (2017). Saket et al (2014) reported that plant height (33.45 cm) was found highest by the application of 5ton ha^{-1} FYM and Bhuiya et al (2017) reported that plant height (34.06 cm) was noted highest in 20 ton ha^{-1} compost manure.

Period of flowering and flat pod observation

It was observed that all the treatments showed similar timing for the first flowering and 80% flowering. But the treatment showed significant differences in the timing of first flat pod observation where the first flat pod was observed earlier in the FYM treatment (96.4 DAS), followed by vermicompost (97.2 DAS) and later (100.0 DAS) in the control. The data are given in table 5. These findings are in close agreement with those of Ceritoglu and Erman (2020), Varun et al (2022), and Shareef et al (2021).

Table 5. Effect of different organic fertilizers on the period of branching, flowering and flat pod observation

Treatments	Date of 1st flowering (DAS)	Date of 80% flowering (DAS)	Date of 1st flat pod observation (DAS)
FYM + 100% NPK	78.2	89.6	96.4[a]
Vermicompost + 100% NPK	78.2	90.0	97.2[ab]
Panchagavya + 100% NPK	80.0	89.4	98.6[bc]
Control (100% NPK)	80.4	90.8	100.0[c]
Grand Mean	79.45	89.95	98.05
SEm (±)	0.73	0.58	0.65
LSD(0.05)	2.24	1.80	2.01
F-test	ns	ns	*
CV (%)	2.18	1.45	1.49

Note: SEm: Standard error of mean, LSD: Least significant difference, CV: Coefficient of variation, ns: non-significant, *: Significant at 5% probability level, values with the same letters in the columns are not significantly different at 5% LSD (Least significant difference) Test.

Number of pods per plant

The number of pods/plant was found highest for FYM (107.18), followed by vermicompost (104.58), panchagavya (97.76), and lowest for control (94.25). A statistically significant difference existed between FYM and the other treatments ($p<0.05$). Number of pods/plant was found significantly increase by 12.06% in FYM, 9.88% in vermicompost and 3.59% in panchagavya over control.

Number of filled pods per plant

FYM had the most filled pods/plant (101.30) followed by vermicompost (95.78) and panchagavya (91.29) whereas the control group had the lowest number of filled pods/plant (86.12). The differences between FYM and other treatments was statistically significant ($p< 0.05$). Number of filled pods/plant was found significantly increase by 14.99% in FYM, 10.09% in vermicompost and 5.66% in panchagavya over control.

Table 6. Effect of different organic fertilizers on yield attributes of lentils (A)

Treatments	No. of pods /plants	No. of filled pods/plant
FYM + 100% NPK	107.18[a]	101.30[a]
Vermicompost + 100% NPK	104.58[ab]	95.78[ab]
Panchagavya + 100% NPK	97.76[bc]	91.29[bc]
Control (100% NPK)	94.25[c]	86.12[c]
Grand Mean	100.94	93.62
SEm (±)	2.66	2.72
LSD(0.05)	8.18	8.39
F-test	*	*
CV (%)	5.88	6.51

Note: SEm: Standard error of mean, LSD: Least significant difference, CV: Coefficient of variation,*: Significant at 5% probability level, values with the same letters in the columns are not significantly different at 5% LSD (Least significant difference) Test.

Biomass per plant

Biomass/ plants was significantly influenced by the application of different treatments. FYM had the highest biomass/plant (79 g) whereas the control had the lowest biomass/plant (55.8 g). Vermicompost was in second and panchagavya was in third position having biomass/plant of 75 g and 68.4 g respectively. Biomass/ plant was found to increase significantly by 29.37% in FYM, 25.6% in vermicompost and 18.42% in panchagavya over control. This finding is in agreement with the finding of Ditta et al (2015). According to Ditta et al (2015), fresh biomass/plant was highest in the ratio of 50:50 rock phosphate and compost.

Number of seeds per pod

No. of seeds/pod from plants was significantly influenced by the application of different treatments. The highest number of seeds/pod (1.87) was found in FYM treatment and it was statistically at par with vermicompost (1.77). The lowest number of seeds/pod was found in control treatment (1.70).

Thousand grain weight

In this parameter, FYM had the highest mean (18.6 g) followed by vermicompost (18.6 g), panchagavya (18 g), and control (17 g) but no significant difference was observed. The data of biomass/plant, number of seeds/pod and 1000 grain weight are given in table 7.

Table 7. Effect of different organic fertilizers on yield attributes of lentil (B)

Treatments	Biomass(g) /plant	No of seeds/pod	1000 grain weight(g)
FYM + 100% NPK	79.0[a]	1.87[a]	18.6
Vermicompost + 100% NPK	75.0[a]	1.77[a]	18.6
Panchagavya + 100% NPK	68.4[ab]	1.74[b]	18.0
Control (100% NPK)	55.8[b]	1.70	17.0
Grand Mean	69.55	1.77	18.05
SEm (±)	4.85	0.03	0.59
LSD(0.05)	14.94	0.10	1.81
F-test	*	*	ns
CV (%)	15.59	3.97	7.28

Overall, the data suggests that FYM is the most effective treatment for all the parameters. Vermicompost and panchagavya were also effective, but not as effective as FYM. The control treatment had the lowest values for all of the parameters.

The findings of above parameter like 1000 grain weight is supported by the findings of Saket et al (2014), Zeidan (2007) and Fatima et al (2018). Saket et al (2014) noted that 5 t ha^{-1} FYM had highest grain weight/plant, number of seeds/ pod (1.56 g) and 1000 grain weight (29.28 g).

Grain yield (kg ha^{-1})

FYM had the highest grain yield (1558 kg ha^{-1}) followed by vermicompost (1434 kg ha^{-1}), and panchagavya (kg ha^{-1}). The lowest grain yield (1172 kg ha^{-1}) was recorded in control. FYM and the other treatments differed statistically significantly ($p<0.005$). Grain yield (kg ha-1) was found significantly increase by 24.78% in FYM, 18.27% in vermicompost and 12.01% in panchagavya over control.

Table 8. Effect of different organic fertilizers on grain yield of lentil (kg ha^{-1})

Treatments	Grain yield (kg ha^{-1})
FYM + 100% NPK	1558[a]
Vermicompost + 100% NPK	1434[ab]
Panchagavya + 100% NPK	1332[bc]
Control (100% NPK)	1172[c]
Grand Mean	1374
SEm (±)	67.99
LSD(0.05)	209.49
F-test	*
CV (%)	11.06

Note: Sem: Standard error of mean, LSD: Least significant difference, CV: Coefficient of variation, ns: non-significant, *: Significant at 5% probability level, values with the same letters in the columns are not significantly different at 5% LSD (Least significant difference) Test.

The above findings related to yield are supported by Singh and Lakhan (2022), Fatima et al (2018), Bhuiya et al (2017) and Sonkarlay et al (2020). Singh and Lakhan (2022) stated that grain yield (1.75 t ha^{-1}) and straw yield (2.12 t ha^{-1}) was highest in 2.5 t ha-1 FYM + 1.25 t ha^{-1} vermicompost.

CONCLUSION

Highest grain yield (1,558 kg ha^{-1}) of lentil was obtained from the application of FYM followed by vermicompost (1,434 kg ha^{-1}), panchagavya (1,332 kg ha^{-1}) and the lowest grain yield (1172 kg ha^{-1}) was obtained in control treatment. Based on the findings, it is strongly recommend to prioritize the use of farm yard manure (FYM) as the preferable organic fertilizers for lentil cultivation. FYM consistently outperformed the other organic fertilizer in terms of various growth and yield parameters. The data clearly showed that FYM application boosted germination percentages, plant height, branch number, and yield parameters such as number of pods, filled pods, biomass/plant, and grain yield/ha. Moreover, FYM's good impact on lentil development and output might contribute to ecologically friendly and sustainable agriculture methods. Therefore, it is strongly

recommended to explore the potential benefits of using FYM in other lentil-growing regions.

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AUTHORS' CONTRIBUTION

Pramod Bhatta and Naresh Joshi conceived and designed the experiments, performed the experiments. Durga Bogati and Kusum Timilsina assisted in data collection. Pramod K.C analyzed and interpreted the data; wrote the final manuscript. Ramesh Bahadur Karki and Prabin Dangi aided in preparation of format, and writing and rectification of the manuscript. Raksha Sharma: Regular constructive comments and support during this research work, guidance during preparation of manuscript as well as revised the final draft of the paper.

CONFLICTS OF INTEREST

The authors have no any conflict of interest to disclose.

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