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Research Article

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CORRELATION AND PATH ANALYSIS FOR YIELD AND YIELD LINKED TRAITS IN WHEAT (*Triticum aestivum* L.)

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ABSTRACT

This study was fixed to estimate the correlation and path analysis for plant height (cm), spike length (cm), 1000-grain weight (g), days to emergence, days to maturity, tillers per square meter, biological yield (g), lodging (%), and grain yield (g) among 22 advanced wheat lines with two checks i.e: Waddan and PS-2005. The replication method known as RCB design with 3 was employed for this experiment. The analysis of variance showed that all 22 wheat advanced lines exhibited significant variation in all studied traits. Mean values for plant height, spike length, 1000-grain weight, days to emergence, days to maturity, tillers per square meter, biological yield, lodging, and grain yield were observed to be 83.84 cm, 11.33cm, 40.74 g, 18, 178, 496, 17.5 kg, 46 and 3928 g respectively. Estimation for yield and yield related attributes specified that correlation of grain yield was extremely remarkable and positive with the traits like spike length, 1000-grain weight, biological yield, tillers/meter^2 and days to emergence whereas, the correlation for plant height, and lodging, exhibited negative association with grain yield along with days to maturity which showed the negative but non-significant effect on grain yield. Path analysis through direct and indirect effect revealed that tillers/meter^2 and days to emergence paramount significant and direct positive effect on yield which summed up that these two traits directly influence grain yield whereas, 1000-grain weight, biological yield, and days to maturity have also showed direct positive but non-significant effect on yield. Based on the results, it can be determined that selecting wheat genotypes to enhance grain yield should focus on yield-contributing traits that show a significant positive relationship and exhibit a significant positive direct effect on grain yield. These traits should emphasized in further selection and can have a dynamic role in breeding systems.

Keywords: Wheat, Correlation, Path analysis, Production traits, Yield.

INTRODUCTION

Wheat (*tritcum aestivum* L.) is a long day plant and comprised about 95% self-pollination. Bread wheat is hexaploid in nature with genomic organization AABBDD and most of the wheat which is cultivated everywhere in the world is hexaploid (Giraldo *et al.*, 2019). Wheat growing area is round about nine million hectare which makes 40% of the total cultivated land. Wheat contributes 11% to the value added agriculture and 2.3% to the country total GDP. This season production of wheat is all time high which is 28.74 million tones. However last year production was 26.77 million tones. In Khyber Pakhtunkhwa wheat cover 47% of total cropped area and 58% of the area possesses to cereals in the province. Climate condition of KPK and whole Pakistan is very much suitable for wheat and is widely adapted to both irrigated and non-irrigated regions of our country. Increased in the wheat production has been achieved in KPK which crossed the bench mark of 1.26m tonnes to reach all time high (1.459m tonnes). Punjab produced 20.8m tonnes whereas; estimated production was 20m (Ahmed *et al.*, 2008). Wheat is considered to be an economically a major crops in terms of nutrition. Wheat is a rich source of various minerals, vitamins, antioxidants, and fiber. Hundred grams of wheat flour contains 341 grams of calories, 12 % water, 14.1 grams protein, 73 grams carbohydrate, 0.5 grams sugar, 9.7 grams fiber and similarly 2.5 grams of fat. Wheat is a worthy source of numerous minerals corresponding to the Selenium, Manganese, Phosphorus, copper, and folate. Apart from that wheat is extensively grown as a raw material for number of foods like semolina, macaroni, starch, and pasta as a diet to the whole world population (Afridi *et al*., 2010). Path analysis can measure both positive and negative direct and indirect effects of one trait on another. Besides, path analysis split correlation association into indirect and direct effect of each trait on yield. Therefore, in order to understand the whole phenomena of yield and the effect of each trait on yield whether it contributing positively or negatively towards yield, path analysis could be recycled as a key tool. Path analysis also provides an effective tool for distributing the correlation association into unidirectional and alternate pathways. So for an effective selection strategy path analysis gives critical values about specific factors and can produce a correlation that can be successfully applied (Singh and Singh, 1998). There is a pressing need to increase productivity to meet people need and to fulfill increasing demand. By applying these terms breeder can understand and tackle the problem and can also enhance the yield up to maximum level (Ahmed *et al*., 2008). And this can be possible through adoptions of high yielding varieties with desirable attributes. The study aimed to identify the superior wheat lines for yield traits, correlation between different morphological traits and their direct and indirect effects on grain yield.

MATERIAL AND METHOD

This research was conducted at Agriculture Research Station (ARS) Baffa Mansehra Pakistan during the growing season 2020. Twenty two wheat genotypes for higher yield, correlation and path analysis were being evaluated, Wadan and PS-2005 were used as a control

check. The experimental material was planted on 05 December 2020 in RCB design having six rows with three replications with row-row distance of 30 cm and plant to plant distance is 10 cm. Suggested traditional practices were carried out for the successful evaluation of wheat advance lines. Three plants were selected randomly for recording the data on yield and yield associated traits from every plot. Data were recorded on following parameters; Days to emergence, Plant height (cm), Spike length (cm), 1000-grain weight, Lodging, Days to maturity, Tillers/meter^2, Biological yield (kg), Grain yield. ANOVA was achieved through R Studio software. LSD test was used for mean comparison. Genotypic correlation between all parameters was calculated through R Studio software. The effects (direct and indirect) for all parameters on grain yield were calculated through path analysis by means of R Studio software.

RESULTS AND DISCUSSION

Days to emergence: Highly significant differences were witnessed for days to emergence across all the genotypes shown in (Table 1). The data ranged from 17 to 19 days. Mean value for this parameter was counted 18 days. Maximum counting for this trait was (19) days was found in genotype G-2 and G-3 followed by genotype G-8 with 18 days, while minimum days to emergence 17 was establish in genotype G-10 (Table 2). Significant genetic diversity for days to emergence among advanced wheat genotypes was similarly described by Chaudhary *et al.,* (2020). Days to emergence showed significant positive correlation with grain yield, while negative and significant with biological yield (Figure 1). Days to emergence exhibited positive direct effect on grain yield with value of 8.086, while spike length showed negative indirect effect thru days to emergence on yield with the value of -7.32, (Figure 2). Our results were accordant to the results of Chaudhary *et al.,* (2020).

Plant Height (cm): Highly significant differences were documented for plant height across all the advanced wheat lines (Table 1). Range values for plant height extended from 73.0 cm to 96.0 cm. The grand mean value was 83.84 cm. Maximum plant height 96 cm was observed in genotype G- 22 which is followed by genotype G-12 and G-13 having plant height 93 cm. Minimum plant height of 73 cm was observed in G-8 (Table 2). Significant genetic diversity for plant height amongst all wheat genotypes was also described by Khan *et al*., (2021). As per co-efficient of correlation, plant height demonstrated positive and significant association with lodging. The rest of the parameters including yield and yield associated traits showed non-significant and negative correlation with plant height apart from days to maturity which showed positive non-significant association. Significant and positive association for plant height was found with lodging which suggests that plant height can be used as indirect selection criteria for lodging resistance (Figure 1). Our results were in accordant to the results of Akram *et al*., (2008). Who also found same result. Plant height exhibited negligible negative direct effect on grain yield with the value of -2.55. It also showed negligible positive indirect effect on grain yield via spike length with value of 3.042 (Figure 2). Negative direct effect on yield was also observed for plant height by Iftikhar *et al*., (2012) therefore, selection for low plant height would ultimately be helpful for improving grain yield.

Spike length (cm): Highly paramount differences were recorded through data analysis for spike length in all advanced wheat lines (Table 1). Range values for spike length were from 10 cm to 13 cm. The grand mean value was 11.33 cm. Maximum spike length was visually examined in genotype G-10 13 cm Minimum spike length 10 cm was visually examined in genotype G-9 (Table 2). A like with the described results of Khan *et al*., (2021). Spike length exhibited positive highly significant association with yield and days to emergence, while negative highly significant with lodging. Whereas non-significant cognition was revealed with days to emergence, 1000 grain weight, tillers/meter square and biological yield (Figure 1). Spike length considered as the main contributors towards yield in wheat as increased in spike length gives more numbers of spikelets per spike and in return higher grain yield. (Meles *et al*., 2017) and Khan *et al*., (2021) also found same results and suggested that increased in spike length positively contributed towards yield in wheat. Direct but negative effect exhibited by spike length on yield with value of -9.07, while positive indirect impact on grain yield through via days to emergence 6.530 (Figure 2). Similar inspections by Barnawal *et al*., (2012) for spike length supported our statistics.

Lodging: ANOVA exhibited results with high level of significance with regard to lodging in all wheat genotypes as given in (Table 1). Range value for lodging extended from 0 to 100. Average value stood at 46. Genotype G-22 exhibited 100 highest value for lodging followed by genotype G-14 90, while genotype G-3 exhibited lowest value 0 for lodging in all genotypes (Table 2). Significant genetic diversity for lodging among wheat genotypes were also reported by LI *et al*., (2020). Correlation study for lodging remained negative highly significant with grain yield as given in (Figure 1). Sarker *et al*., (2007) and Zuber *et al*.,(1999). Stagnant negative direct effect was recorded by lodging on yield -0.934, whereas positive direct effect on grain yield was observed by spike length via lodging with value of 5.509 as shown in (Figure 2). Our results were close to the finding of Sarker *et al*., (2007) and Zuber *et al*., (1999). Thicker stems and heavier stems were characteristics for better lodging resistance, whereas lodging also depends upon ear weight and plant height. Most of the fresh weight traits correlated better to lodging resistance compare to corresponding dry matter parameters. So selection for the characters which negatively contributing towards lodging resistant in wheat could be proved very effective in the improvement of lodging resistance varieties in wheat.

Days to Maturity: ANOVA for days to maturity revealed highly significant differences for all genotypes (Table 1) Days to maturity were distributed over a range of 173 to 180 days with the mean value of 175 days. Maximum days for maturity 180 was attained by genotype G-5 followed by genotype G-13 with 178 days. Minimum days to maturity 173 days was recorded for genotype G-21 (Table 2). Our observation are comparable with the finding of Anwar *et al*., (2009) they found significant results for days to maturity in all genotype. Correlation for days to maturity revealed negative non-significant relationship between grain yield, tillers per square meter, biological yield and lodging (Figure 1) Early maturity is considered a desirable attribute in most crops. Similar observation has been put forward by Siyal *et al*., (2021) which confirmed that days took to maturity play a important role in wheat production. Negligible direct positive impact on grain yield showed by days to maturity with value of 3.553, whereas spike length exhibited negligible indirect impact on yield through days to maturity -1.896 (Figure 2). Same finding were also put forward by Akram *et al.,* (2008) and Anwar *et al.,* (2009). Therefore selection for genotypes for higher yield can be done by keeping in view of number of days taken to maturity.

Tillers/meter^2: Mean square perceived results with high level of significance for tillers/m^2 (Table 1). Data for tillers/m^2 ranges from 441 to 545. Grand mean value for tillers/meter^2 was 496. Maximum value for tillers/

meter^2 545 was recorded for genotype G-8 followed by genotype G-21 526 (Table 2). The minimum value 441 exhibited by genotype G-1. Likewise supporting estimates were also described by Faisal *et al.* (2015). Highly significant and positive association was experienced with yield, while lodging associated negative non-significant correlation with tillers/meter$^{2.}$ (Figure 1). These finding were in authorization with the finding of Shahid *et al*., (2002) and Barnawal *et al*., (2012). These outcomes demonstrated that number of tillers/meter^2 is a significant yield contributing variable and it can prompt more number of grain/spike alongside yield. Significant positive direct effect were revealed by tillers/meter^2 on yield with value of 2.795. Negative indirect impact on grain yield was experienced by spike length through tillers/meter^2 on grain yield -3.507 (Figure 2). Our finding was in accordant to the result of Rachana *et al*., (2021). So these results indicated that the numbers of tillers/m^2 is responsible for maximum yield and for running successful breeding programs tillers/m^2 could be used as direct selection parameter for yield.

Biological Yield (kg): Statistical analysis through ANOVA indicated highly significant differences for biological yield in all genotypes as shown in (Table 1). Pursuant to mean data of biological yield the range varies from 16.5 to 18.7 kg/plot. The grand mean value stood at 17.5 kg/plot. The maximum value of biological yield 18.7 kg was exhibited by genotype G-20 followed by genotype G-8 with value of18.5 kg, whereas the minimum value stood at 16.5 kg by genotype G-13(Table 2). High significant variation for biological yield was also reported by Hussain Ali, I., (2012). Biological yield positively and highly significantly correlated with tillers per square meter, whereas lodging and grain yield associated non-significant negative correlation with biological yield (Figure 1). The conclusion of this study was accordance to the result of Mollasadeghi *et al*., (2011) they reported the direct and positive effect of biological yield on grain yield and found it most contributing in yield. Positive direct effect were exhibited by biological yield on grain yield with value of 1.259, while negative indirect effects on grain yield was exhibited by days to emergence via biological yield -3.744 as shown in (Figure 2) The conclusion of this study was accordance to the result of Mollasadeghi *et al.,* (2011) and Rani *et al.,* (2018) reported the direct and positive effect of biological yield on grain yield and found it most contributing in yield. These finding suggest that biological yield can be used as direct selection criteria for yield.

1000- Grain Weight: High variation was observed amongst all the wheat advanced lines for 1000 grain weight (Table 1). Whole data was ranged from 39.1 to 42.4 gm for 1000 grain weight. Average values for 1000 grain weight were 40.74 gm. Genotype G-13 and G-14 revealed maximum 1000 grain weight 42.4 followed by genotype G-2 41.4 whereas, minimum grain weight were 39.1 gm observed in genotype G-3 (Table 2). Highly significant genetic diversity for said trait among all wheat genotypes was also reported by Ahmed *et al*., (2008). The association of thousand grain weight showed negative highly significant correlation with lodging. Rest of the parameters including yield and yield associated traits showed positive non-significant correlation with thousand grain weight (Figure 1). Positive association between 1000-grain weight and grain yield/plant is also corroborated by the earlier finding of Shoran *et al*., (2000), Ahmed *et al.,* (2008). Direct positive effect was exhibited by thousand-grain weight on grain yield 1.437 whereas, negative and indirect effect via spike length on grain yield -2.985 (Figure 2). Iftikhar *et al*., (2012) and Rani *et al.,* (2018) also confirmed that thousand-grain weight possessed maximum positive direct impact on yield. Thousand grain weight possessing positive relation along with direct effect on yield could be proved suitable selection criteria for developing high yielding varieties.

Grain Yield: ANOVA showed highly significant differences for grain yield (Table 1). Mean data for grain yield ranges from 3086 gm to 5003 gm & the grand mean value stood at 3928 gm. The genotype G-8 exhibited highest value for grain yield 5003 gm followed by genotypes G-21 4364 sequentially whereas genotype G-1 3086 stood at lowest mean value (Table 2). Majumder *et al*., (2008) and Ibrahim (2019) also found similar results. Grain yield correlation was found positive highly significant with tillers/m^2 and spike length, while positive and significant with days to emergence (Figure 1). Grain yield correlation with lodging was found negative highly significant. Similar finding in wheat was also observed by Shahid *et al.,* (2002) and Barnawal *et al.,* (2012). Positive and direct effect of grain yield was found with thousand grain weight, biological yield, tillers/m^2, days to emergence, days to maturity, whereas negative direct effect was found with plant height, lodging and spike length (Figure 2). Same finding was put forward by Mollasadeghi *et al.,* (2011) and Rani *et al.,* (2018).

Table 1: Mean square values of all parameters for Wheat Advanced lines

Traits	Replications (03)	Genotypes (22)	Error (42)	CV (%)
Plant height	5.56	74.02**	6.40	3.01
Spike length	0.42	1.55**	0.40	5.63
1000 GW	0.04	3.49**	0.05	0.55
Days to emergence	0.06	0.82**	0.31	3.10
Days to maturity	2.46	5.91**	0.97	0.56
Biological yield	0.12	0.42**	0.08	1.67
Tillers meter/2	78.97	1261.9**	68.2	1.66
Lodging	89.8	1905.7**	715.2	57
Grain yield	36370	361116**	24189	3.95

Table 2: Mean values of Plant height, Spike length, and 1000 GW for 22 wheat advanced lines.

Genotypes	Plant height (cm)	Spike length (cm)	1000 GW (gm)	Genotypes	Plant height (cm)	Spike length (cm)	1000 GW (gm)
G-1	87.0	10.3	40.3	**G-13**	89.3	11.3	40.3
G-2	79.3	12.3	41.0	**G-14**	86.7	10.3	39.2
G-3	81.7	11.7	39.2	**G-15**	77.0	10.7	39.2
G-4	87.3	12.0	40.3	**G-16**	84.0	11.7	41.3
G-5	85.0	12.0	40.2	**G-17**	77.7	10.3	39.9
G-6	81.3	11.7	41.3	**G-18**	75.3	11.7	41.3
G-7	88.0	10.3	41.2	**G-19**	85.0	11.7	42.3
G-8	73.7	12.5	42.3	**G-20**	85.3	11.0	42.3
G-9	85.7	11.0	40.3	**G-21**	83.7	12.3	40.2
G-10	84.3	10.7	40.2	**G-22**	95.0	11.3	39.2
G-11	84.7	10.7	42.2	**Grand Mean**	83.84	11.33	40.74
G-12	87.7	11.7	42.2	**LSD Value at 5%**	4.16	1.05	0.37

Table 2: Mean values of days to Emergence, Days to Maturity, Biological yield for 22 wheat advanced lines.

Genotypes	Days to emergence	Days to maturity	Biological yield (kg)	Genotypes	Days to emergence	Days to maturity	Biological yield (kg)
G-1	17.6	176.0	17.8	**G-13**	18.3	177.3	16.8
G-2	19.0	176.0	17.3	**G-14**	18.0	175.7	17.3
G-3	18.6	176.0	17.9	**G-15**	18.3	174.3	17.3
G-4	17.6	174.7	17.4	**G-16**	18.3	174.7	17.6
G-5	18.6	179.3	17.0	**G-17**	17.0	176.0	17.9
G-6	18.0	177.3	17.5	**G-18**	17.6	176.7	17.2
G-7	17.6	175.3	17.6	**G-19**	18.0	177.0	17.3
G-8	18.0	174.7	18.2	**G-20**	18.6	174.3	17.8
G-9	18.3	176.0	18.2	**G-21**	18.6	173.7	17.3
G-10	17.0	176.7	17.9	**G-22**	17.6	177.0	18.0
G-11	18.0	173.7	17.4	**Grand Mean**	18.0	175	17.5
G-12	18.3	177.3	17.9	**LSD Value at 5%**	0.92	1.62	0.48

Table 2: Mean values of Tillers/$m^{2,}$ Lodging, Grain yield for 22 Wheat Advance lines.

Genotypes	Tillers/meter^2	Lodging	Grain yield (g)	Genotypes	Tillers/meter^2	Lodging	Grain yield (g)
G-1	451	48	3089	**G-13**	471	43	4014
G-2	477	32	4006	**G-14**	509	93	3705
G-3	496	15	4040	**G-15**	476	90	3714
G-4	487	38	4015	**G-16**	482	82	4009
G-5	509	47	4029	**G-17**	501	63	3393
G-6	511	20	4346	**G-18**	492	23	4080
G-7	487	43	3397	**G-19**	472	50	4016
G-8	540	17	4700	**G-20**	499	63	3717
G-9	519	22	4008	**G-21**	517	25	4364
G-10	511	33	4012	**G-22**	516	97	3724
G-11	490	33	4015	**Grand Mean**	496	46	3928
G-12	515	38	4029	**LSD Value 5%**	13.6	44.0	256

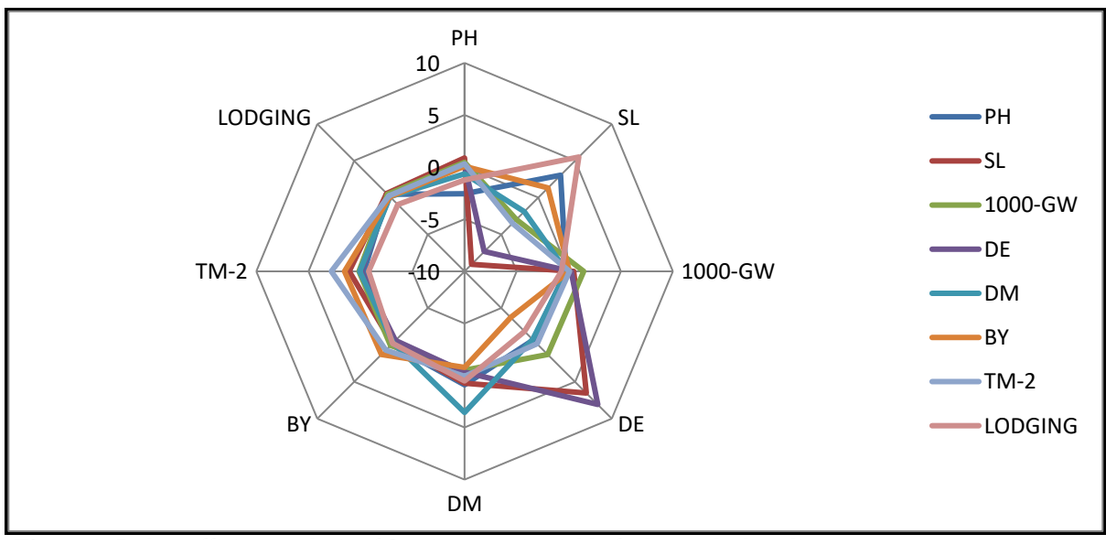

Figure 1: Path coefficient analysis of 9 traits on grain yield of advanced wheat lines.

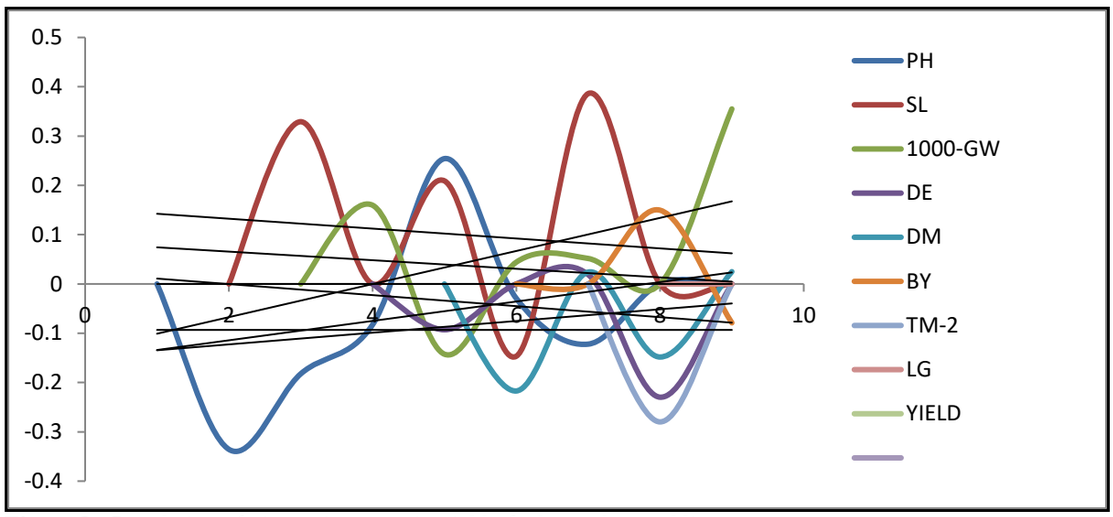

Figure 2: Correlation of nine traits on grain yield of wheat advanced lines.

CONCLUSION AND RECOMMENDATION

It is concluded that all tested wheat advanced lines revealed highly significant variation for all traits which confirmed the existence of vast genetic diversity and variations hence, these genotypes could be used to explore new genetic combinations in further breeding programs for improvement in wheat production. Among the tested wheat genotypes on the basis of mean performances genotypes (G-8) performed better and depicted good results for yield and linked traits like spike length, 1000 grain weight, tillers/m^2, and days to emergence, etc. Therefore the said genotype has the potential to give good results and suggested to be utilized in upcoming wheat breeding programs. Correlation studies related to yield and all other parameters suggest the importance of spike length, tillers/m^2, days to emergence, and thousand grain weight which present a positive attitude of relation towards grain yield whereas, 1000-grain weight, days to emergence, days to maturity, tillers/m^2 and biological yield possess a direct positive effect on yield. Hence, it is recommended that attention must be diverted to these traits so that the best results can be achieved for developing high yielding cultivars and eventual goal of a breeding program can be accomplished.

CONFLICT OF INTEREST

The authors declared that they have no conflict of interest for the publication of the manuscript**.**

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