



Correlation and Path Coefficient Analysis of Yield and yield-related attributes of wheat (*Triticum sp. L*) genotypes under drought and heat stress conditions.

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1. Abstract

A field experiment was conducted where twenty genotypes of wheat were evaluated in heat stress conditions with an alpha lattice design in tropical region of Nepal to evaluate the relationship between yield and yield-attributing and determine the direct and indirect effect of yield-attributing the yield of wheat through correlation and path coefficient analysis. Path analysis plays a significant role in determining such effects showing the importance of various yield-attributing traits. Here, we discussed how different yield attributes characters affect the grain yield. Among the traits, PH, NGPS, NSPS, SL, Test weight, and S/m² have a positive direct effect on grain yield. Among these traits, S/m²(0.61267) had the strongest direct effect on grain yield. This show that only grain weight is not enough in deciding the qualities of genotypes. So, it is necessary to study the correlation among its various traits. This will be better for the selection of varieties in the plant breeding program.

Keywords: Genotype, phenotype, traits, path analysis, selection

2. Introduction

Wheat is the world's major staple crop, having the supreme rank in production and productivity contributing to about 30% of the world grain production and 50% of world grain trade belonging to Poaceae family (Padam Bahadur Poudel and Mukti Ram Poudel 2020). In Nepal, it is the third most important staple food both in terms of area and production after rice and maize in Nepal(Vijayalaxmi et al. 2012). Wheat has fantastic nutritional background with 12.1% protein,

1.8% lipid, 1.8% ash, 2.0% reducing sugars, 6.75 pentosans, 9.2% starch, 70% total carbohydrates and supplies 314 Kcal/100g of food along with ample source of minerals and vitamins viz., Fe(4.1mg/100g), Ca(37 mg/100g, riboflavin (0.13mg/100g), thiamine(0.45mg/100g), and nicotinic acid (5.4 mg/100 mg) (Iqbal et al. 2017). According to FAO, by 2050, 198 million tonnes are additionally required for the world to meet wheat demands and in developing countries, there should be a 77% increment in wheat production. Especially in developing countries, it is forecasted that to fulfil the need of increasing world population for 2020 ranges between 840 and 1050 million tons so increasing the yield is a prime need to meet the feeding demand of the world in the 21st century to assure food security (Iqbal et al. 2017) because, by the end of 21st century, an increase of 1.8-5.8°C in day-night temperature is estimated by global climate change (Ihsan et al. 2019). According to the FAO, the annual cereal supply will need to increase by about one million metric tons by 2050 to feed the anticipated population of 9.1 billion people. Increased agricultural output and productivity are needed to meet rising food demand in the twenty-first century (Padam Bahadur Poudel and Mukti Ram Poudel 2020).

(Iqbal et al. 2017) suggested that the temperature level beyond the threshold level for some time which can summon and cause destructive damage to the growth and development of a plant is considered heat stress while the ability of a plant can withstand and tolerate to give economic yield in presence of higher temperature is referred as heat tolerance. High temperature and drought are the significant elements that harm cereal yield (Raza et al. 2019) because the threshold temperature for wheat is 26°C and above this temperature, remarkable changes in growth habits occur (Wahid et al. 2007). There is a significant effect of the drought, mainly in a country like Nepal; based on rainfed farming. The rise in temperature and precipitation patterns became a serious issue for the wheat-growing region. The production level, yield quality and cropping cycle of wheat are related to the drought status. More than 80% of the population in the western area was negatively impacted by the summer 2015 drought, which had a significant negative impact on agricultural productivity(Hamal et al. 2020).

Wheat farming will be impacted, as wheat is sensitive to high temperatures, drought, and heat stress. After rice and maize, wheat is the major cereal grain cultivated in Nepal, ranking third in terms of both acreage and yield. In many places of the world, including Nepal, drought and heat stress are serious issues in wheat production. In Nepal, wheat is generally sown after rice harvesting, which delays the optimal sowing time for wheat, resulting in higher temperature stress during grain filling and low wheat yields(Padam Bahadur Poudel and Mukti Ram Poudel 2020). Terai's long-term meteorological parameters show that the winter days are getting a little later and shorter, while the hot summer days are getting longer. Wheat farming in the Indo Gangetic region, particularly the Nepal Terai, could be harmed by this type of temperature fluctuation(Puri, Gautam, and Kumar Joshi, n.d.). Nearly half of Nepal's wheat-growing area, which is entirely in the Terai (plain) region, is affected by terminal heat stress. Beginning in mid-March, this area is subjected to western hot winds and a dramatic temperature increase (min and max), resulting in grain shriveling up (Puri, Gautam, and Kumar Joshi n.d.). From 1980 to 2015, the world experienced the warmest period in its 1400-year history, with global average temperatures rising to around 0.85°C (Padam Bahadur Poudel and Mukti Ram Poudel 2020). So, wheat production has been a global constraint for all breeders and producers.

It is the most crucial crop in the case of nutritional development and also helps in the economic growth of the nation. Wheat productivity has increased at a rate of 1.75 percent over the last five years, but gross production has only increased by 3.67 percent for the fourth year in a row. The record production of wheat, 80.6 mt, from 27.8 million hectares, was achieved in 2010, and the

target of 90 mt of wheat production by 2030 may be achievable (DWR,2010). However, due to increasing population pressure, an area under cultivation is consistently diminishing, which may be a problem (Baranwal et al., 2012) In the recent trend, the development of best genotypes with linking of yield attributing traits seems quite good for the stability of wheat performance. The amount of genotypic diversity present in a population for the characteristics affects the development of improved cultivars capable of providing higher yields under diverse agro-climatic conditions. (Ahmad et al., 2018)

Grain yield depends upon various traits and their effect on it. It can't conclude the performance of any genotype by analyzing a single contribution of yield. Correlation and path analysis studies assist plant breeders in crop selection by delivering a good knowledge of yield components. (Baranwal et al., 2012) Correlation studies are taken to determine traits that are closely linked with grain production, so that the optimal combination of these traits may be accumulated in a particular genotype. (Ahmad et al., 2018) Path analysis is important for determining whether factors have an impact on other variables. The information gathered might be used to generate new wheat varieties with great yield potential using novel breeding tactics and selection procedures. (Ayer et al., 2017)

3. Methods and methodology:

3.1 Site description and experimental material:

The field experiment was conducted at the Institute of Agriculture and Animal Science Paklihawa, Rupandehi, Nepal. It is geographically located with an altitude of 100 masl, latitude 27°30' N, 83°27' E, and 79 m above sea level. 20 different types of wheat genotypes were collected from National Wheat Research Program (NWRP), Bhairahawa.

3.2 Experimental Design:

The evaluation of different genotypes in the experimental site was carried out using an Alpha lattice design as shown in Figure 1. The length and breadth of the total field were 24metre. Two replications were prepared which were separated by a 1m distance. Each replication consists of five blocks while each block contains four plots. The plot size was 4m × 2.5m.

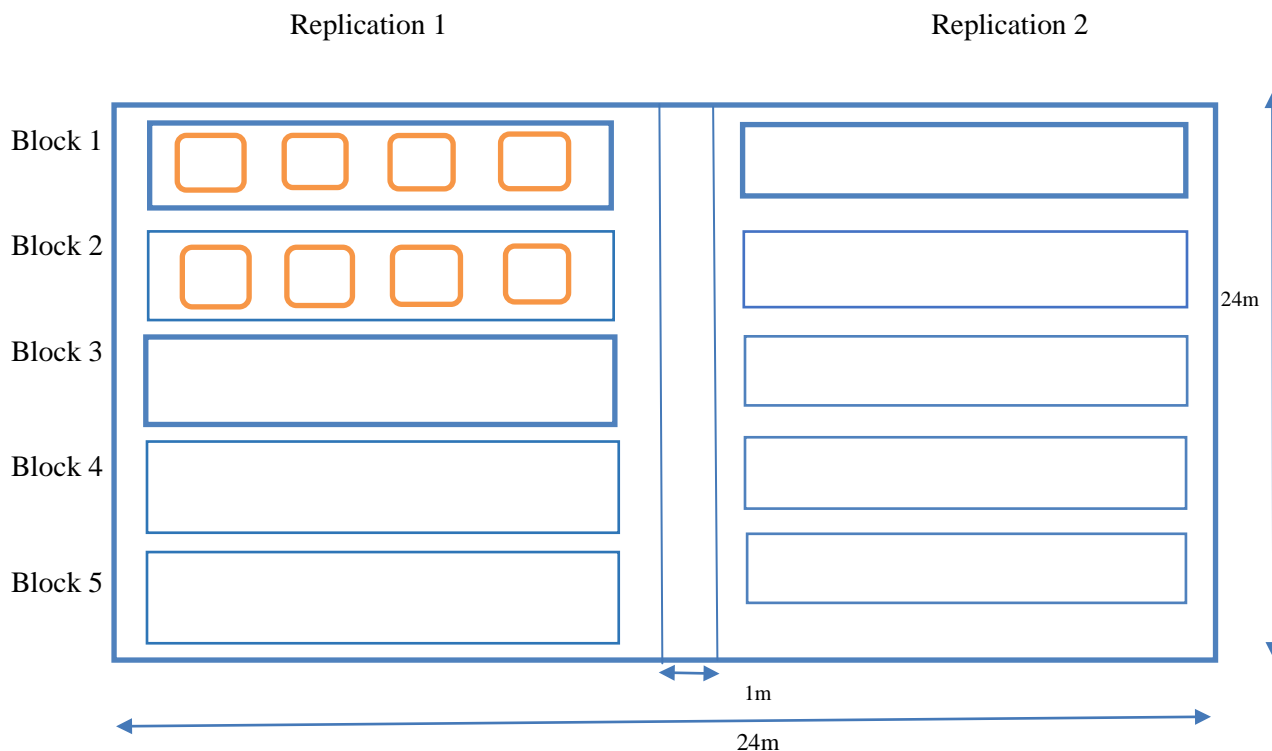


Figure 1: Alpha Lattice Design Layout

3.3 Land preparation, sowing, and fertilizer application:

For the preparation of land, deep plowing was done with the aid of a tractor followed by two harrowing and manual labeling. Line sowing was done on 26th December

Compost manure at the rate of 5 ton/ha and the individual plots was fertilized with a recommended dose of 50:50:20 kg NPK/ ha. All doses of fertilizer were applied before sowing.

Table 1: List of wheat genotypes along with their origin.

S.N.	Name of wheat genotypes	Origin
1.	Gautam	Nepal
2.	BL 4669	Nepal
3.	NL 1412	CIMMYT, Mexico
4.	BL 4407	Nepal
5.	NL 1368	CIMMYT, Mexico

6.	NL 1417	CIMMYT, Mexico
7.	Bhirkuti	CIMMYT, Mexico
8.	BL 4919	Nepal
9.	NL 1376	CIMMYT, Mexico
10.	NL 1179	CIMMYT, Mexico
11.	NL 1350	CIMMYT, Mexico
12.	NL 1387	CIMMYT, Mexico
13.	NL 1350	CIMMYT, Mexico
14.	NL 1420	CIMMYT, Mexico
15.	NL 1384	CIMMYT, Mexico
16.	NL 1346	CIMMYT, Mexico
17.	NL 1404	CIMMYT, Mexico
18.	NL 1413	CIMMYT, Mexico
19.	NL 1386	CIMMYT, Mexico
20.	NL 1381	CIMMYT, Mexico

3.5 Agro-metrological data:

Weather data was recorded in IAAS Paklihawa, Bhairahawa during the experimental period (26th December 2021 to 14th & 17th April 2022)

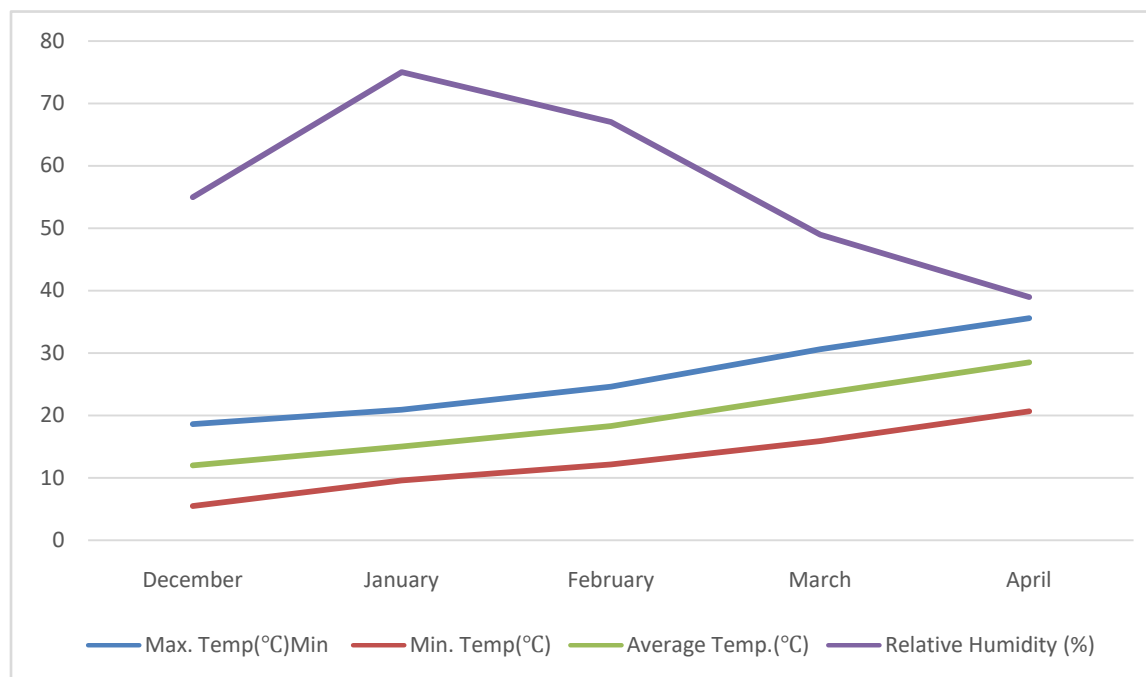


Figure 2: Weather data from the experimental site during the crop growing season.

3.6 Traits that are studied:

Ten sample plants were selected randomly from each plot to collect data. Yield (Biological and Grain) and Yield attributing traits like Plant height (PH), Spike length (SL), Spike weight (SW), Plant population per m² area (S/m²), Number of grains per spike (NGPS), Number of spike per spikelet (NSPS), 1000 kernels weight (TKW) and Harvest Index (HI) were noted.

3.8 Statistical Analysis :

Data were entered by using Microsoft Excel Spreadsheet Software. Co-relation and path coefficient analysis was done by using SPSS and Microsoft Excel.

4. Result and discussion:

Association of characters

From table 1, it is verified that the genotypic correlation coefficients and phenotypic correlation coefficients showed equal magnitude which revealed that the presence of inherent genetic relationships among various characters is more likely dependent on the environment.

PHENOTYPIC AND GENOTYPIC CORRELATION:

Genotypic correlations among the 20 genotypes of wheat were presented in Table 1. The table showed that plant height has a positive genotypic correlation with all the studied traits except spike per meter square (-0.352). For plant height, (Upadhyay 2020) also found the same result to spike per meter square and spike length. It shows significant positive relation with spike length (0.643), spike weight (0.561), test weight (0.504), and grain yield (0.317) for genotypic levels. For plant height, (Thapa, Jaisi, and Poudel 2022) also found the same result with grain yield.

The number of grains per spike has a positive genotypic correlation except for test weight (-0.141) and spike per meter square (-0.267) with all the studied traits. It shows positive and highly significant relation with spike length (0.426) and spikes weight (0.610) for genotypic levels. It shows a positive non-significant correlation with grain yield (0.130) for genotypic levels. For NGPS, (Thapa, Jaisi, and Poudel 2022) also found the same result with test weight and plant height.

The number of spikes per meter square has a positive correlation with all the traits except spike length (-0.149) and test weight (-0.062) for both genotypic levels. It shows a positive and significant correlation with grain yield (0.318) for genotypic and phenotypic levels. For NSPS, (Thapa, Jaisi, and Poudel 2022) also found the same result with test weight.

Spike length has a positive correlation with all the studied traits except spike per meter square (-0.412) for both genotypic levels. It shows positive and highly significant relation with spike weight (0.541), test weight (0.501), NGPS (0.426), PH (0.643), and negative and highly significant with spike per meter square (-0.412) for genotypic levels. For spike length, (Upadhyay 2020) also found the same result with grain yield. For SL, (Thapa, Jaisi, and Poudel 2022) also found the same results with spike weight, grain yield, and NSPS.

Spike weight has a positive relationship with all the studied traits except spike per meter square (-0.428) for both genotypic levels but has a negative and highly significant relation with spike per meter square. It shows positive relation with grain yield (0.233). It shows positive and highly significant with plant height (0.561), NGPS (0.610), spike length (0.501), and test weight (0.403) for both genotypic levels.

Test weight has a positive correlation with all the studied traits except NGPS (-0.141), NSPS (-0.062), and spike per meter square (-0.281) for genotypic levels. It shows positive and highly significant relationship with plant height (0.504), spike length (0.501), and spike weight (0.403) for both levels. For test weight, (Upadhyay 2020) also found the same result with spike length.

Spike per meter square has a negative and significant relation with plant height (-0.352), spike length (-0.412), spike weight (-0.428), and positive relation with grain yield for genotypic and levels with studied traits. Only the NSPS (0.093) has a positive correlation for both genotypic and phenotypic levels. For spike per meter square, (Upadhyay 2020) also found the same result with plant height.

Grain yield has a positive correlation with all the studied traits. It shows significant positive relation with plant height (0.317), NSPS (0.318), and spike per meter square (0.365) for both genotypic and phenotypic levels.

Table 1. Genotypic correlation coefficient of the 8 quantitative traits of wheat genotypes at Rupandehi, Bhairahawa under drought and heat stress condition.

Correlations

	PH	NGPS	NSPS	SL	SW	Test weight	S/m ²	Yield
PH	1	0.273	0.027	.643**	.561**	.504**	-.352*	.317*
NGPS	0.273	1	0.276	.426**	.610**	-0.141	-0.267	0.130
NSPS	0.027	0.276	1	-0.149	0.282	-0.062	0.093	.318*
SL	.643**	.426**	-0.149	1	.541**	.501**	-.412**	0.244
SW	.561**	.610**	0.282	.541**	1	.403**	-.428**	0.233
Test weight	.504**	-0.141	-0.062	.501**	.403**	1	-0.281	0.310
S/m ²	-.352*	-0.267	0.093	-.412**	-.428**	-0.281	1	.365*
Yield	.317*	0.130	.318*	0.244	0.233	0.310	.365*	1

** . Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

PH= plant height, NGPS= number of grains per spike, SL= spike length, S/m²= spike per meter square

PATH COEFFICIENT OF DROUGHT STRESS CONDITION:

The path coefficient is a standard partial regression analysis that divides the correlation coefficient into direct and indirect effects. In this research, we studied about response variable grain yield (GY) and seven predictor variables: Plant height (PH), No. of grains per spike (NGPS), No. of spikelets per spike (NSPS), Spike length (SL), Spike weight (SW), Test weight and Spike per meter square (S/m²). (Table 2)

Direct effect:

It was observed that S/m² has the highest positive direct effect on grain yield under the drought stress condition (0.612). It is followed by test weight (0.3228). Other traits that exert positive direct effects on Grain yield are PH (0.213), NGPS (0.136), NSPS (0.27), SL (0.187), and Test weight (0.322). This indicates that increase in any one of the above traits may directly contribute towards grain yield. Here, S/m² has the greatest contribution to increasing grain yield. Upadhyay (2020) and (Mujahid. et al., 2004) research findings were in line with this finding. (Thakur et al., 2018) also reported that 1000 grain weight have direct effect on grain yield per plant. Spike weight exerted a negative direct effect on grain yield (-0.016).

Spike length, thousand kernel weight, number of spike per meter square (Khan and Naqvi 2012) (Mohammad et.al 2002), number of grains per spike have direct positive effect on grain yield (Upadhyay 2020) and (Singh et al. 2012). The traits that directly affect grain yield can be selected in future for better performance of plant (Nasri et al. 2014) .

Indirect effect

Plant height possessed the highest positive indirect effect on grain yield via the test weight (0.162). It is followed by the values of spike length positive indirect effect on grain yield via test

weight (0.161). After that again, positive indirect effect of spike length on grain yield via plant height (0.137).

Spike weight possesses a highest negative indirect effect via S/m² (-0.262) on grain yield. It is followed by spike length indirect negative effect on grain yield via S/m² (-0.252). Then, plant height possesses negative indirect value via S/m² (-0.215) on grain yield.

Table 2: Path Coefficient analysis showing direct and indirect effects of seven traits on grain yield.

	PH	NGPS	NSPS	SL	SW	Test weight	S/m ²
Via PH	0.21373	0.058244	0.005688	0.137428	0.119903	0.10772	-0.07523
Via NGPS	0.037198	0.1365	0.037643	0.058149	0.083265	-0.0193	-0.03646
Via NSPS	0.007188	0.074484	0.27009	-0.04023	0.076237	-0.01683	0.025222
Via SL	0.120845	0.080062	-0.028	0.18794	0.101676	0.094158	-0.07743
Via SW	-0.00898	-0.00977	-0.00452	-0.00866	-0.01601	-0.00645	0.006852
Via Test weight	0.162691	-0.04564	-0.02012	0.161723	0.130088	0.3228	-0.09063
Via S/m ²	-0.21566	-0.16363	0.057214	-0.25242	-0.26222	-0.17202	0.61267
Yield	0.317011	0.130257	0.318006	0.243927	0.232936	0.310081	0.364993

0.317	PH
0.130	NGPS
0.318	NSPS
0.244	SL
0.233	SW
0.310	Test weight
0.365	S/m ²

6. Conclusion

The correlation coefficient of the above-studied traits shows a positive correlation for genotypic levels with grain yield. So, from the above study, the number of spikelets per spike exerted the greatest influence directly and indirectly upon grain yield. Therefore, significant positive correlated traits having a positive direct effect on grain yields like NSPS, PH, and S/m² of wheat should be given much attention while selecting genotypes as these characters are helpful for indirect selection. In pathway coefficient analysis, S/m² have strong direct positive effect on grain which was followed by test weight. For better performance, the traits that have positive direct affect on grain yield are to be selected.

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