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Correlation and Path Coefficient Analysis of Traits Associated to Grain Protein Concentration and Yield in Wheat (*Triticum aestivum* L.) Cultivars

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ABSTRACT

*The present investigation was carried out to study the path coefficient and correlation analysis for 10 and 15 metric characters of three wheat cultivars were grown under two nitrogen (N) doses @120 and 180 kg N ha^{-1} respectively at Punjab Agricultural University, Ludhiana. The correlation analysis showed significant positive correlation of biological yield (r = 0.9766**), total plant nitrogen at physiological maturity (r = 0.9688**), grain protein yield (r = 0.9069**) and grain protein concentration (r = 0.8236**) on grain yield. Further path analysis was performed to partition the Pearson correlation into direct and indirect effects. Path analysis revealed that vegetative nitrogen had more direct ($P_{9\ 11}$ = 0.5329) significant positive influence on grain yield. Vegetative nitrogen at maturity significant positively correlated with remobilized (r_{93} = 0.6764) and it contribute more indirectly through grain protein yield ($r_{92}P_{2\ 11}$ = 0.2607). Remobilized nitrogen had negative direct effect on grain yield ($P_{3\ 11}$ = -0.2516). A significant positive correlation of grain yield with harvest index (r =0.9833**) followed by vegetative nitrogen at milky stage (r = 0.9693**). Correlation between accumulated dry matter at post anthesis stage had significantly positive (r = 0.8543**) correlation.*

Key words: *Triticum aestivum, Grain, Spikes, Nitrogen*

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the source of sustenance to more than half of the world population and is the second most important cereal crop after rice. Wheat grain has various distinguishing properties due to which it is used to manufacture different machine and hand made products. It occupies an area of 302.27 lakh hectares with the production and yield of 93.50 million tonnes and 3093 kg/ha, respectively[1]. Nitrogen is a vital component of chlorophyll and metabolic enzyme activities, and is the main restraining elements of crop production[6]. Several studies have showed a reduction in grain number per unit area (GNa) with N deficiency before anthesis[2], and a strong positive correlation between GNa and spike N content at anthesis[3]. However, researchers confirmed the strong correlation between GNa and spike dry matter (DM). Application of nitrogen is known to mainly increase the gluten strength, protein content, protein fractions and sedimentation value *etc.*

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Therefore, availability of nitrogen to wheat during various phases of its growth and development is an important factor influencing the yield and quality of grain[9]. The information about path and correlation analysis among characters under selection is very helpful for predicting genetic progress in hybridization programme. Increasing nitrogen fertilizer and reducing irrigation are common strategies to increase grain protein concentration in spring wheat[4]. The chief factor which most influencing wheat quality is nitrogen fertilization, although degree of influence is governed by annual weather condition and by residual soil nitrogen[7].

Therefore, the present work was made to study the extent of path coefficients and correlation among various characters related to grain protein concentration and yield of wheat cultivars.

MATERIAL AND METHODS

The experiment was carried out at the experimental area and laboratories of the Department of Botany in Punjab Agricultural University, Ludhiana. Three wheat cultivars (PBW-550, PBW-502 and PBW-343) were grown under field conditions. The experimental design was a split plot with three replications and row to row distance at 22.4 cm. Nitrogen was applied at a rate of 120 and 180 kg N ha^{-1} respectively. The recommended package of practices for wheat crop was followed to raise the crop. The characters used for correlation and path analysis were grain protein concentration, grain protein yield at maturity, remobilized nitrogen at post anthesis, biological yield, number of spikes per plant, number of kernels per spike, 1000-kernels weight, total plant nitrogen at maturity, vegetative nitrogen at maturity, remobilization efficiency at post anthesis and grain yield. The traits used for correlation between grain yield and traits at different stages in wheat were total plant dry matter at anthesis stage (TDMA), total plant nitrogen at anthesis stage (TPNA), vegetative nitrogen at anthesis + 4days stage (VG4D), vegetative nitrogen at anthesis + 8 days stage (VG8D), vegetative nitrogen at anthesis + 12 days stage (VG12D), vegetative nitrogen at milky stage (VGM), vegetative nitrogen at soft dough stage (VGS), maximum vegetative nitrogen at post anthesis stage (MXN), harvest index at physiological maturity stage (HI), nitrogen harvest index at physiological maturity stage (NHI), sum of harvest index and nitrogen harvest index (SUM), total plant dry matter at physiological maturity stage (TDMM), accumulated nitrogen at post anthesis stage (ACCN), accumulated dry matter at post anthesis stage (ACCDM), Grain yield at physiological maturity stage (GY).

RESULT AND DISCUSSION

The grain yield was highly positively correlated with biological yield (r = 0.9766) followed by total plant nitrogen at maturity (r = 0.9688), remobilized nitrogen at post anthesis (r = 0.9296), number of kernels per spike (r = 0.9195), grain protein yield (r = 0.9069), number of spikes per plant (r = 0.8973), grain protein concentration (r = 0.8236), remobilization efficiency (r = 0.8068), while vegetative nitrogen at maturity (r = 0.4517) had no correlation with grain yield (Table 1).

The correlation of remobilization efficiency was high with grain protein concentration (r = 0.9183) followed by grain protein yield (r = 0.9093), number of kernels per spike (r = 0.8652), total plant nitrogen at maturity (r = 0.8232), number of spikes per plant (r = 0.7574), biological yield (r = 0.7111). Vegetative nitrogen at maturity showed no correlation with remobilization efficiency. Number of kernels highly correlated with grain protein yield (r = 0.9092). 1000-grain weight had no correlation while biological yield showed maximum correlation (r = 0.9490) with total plant nitrogen at maturity followed by grain protein yield (r = 0.9358). Correlation between number of kernels per spike and grain protein yield was maximum.

Path coefficient analysis divides the correlation coefficient analysis into direct and indirect effects[5]. It allows, then the separation of direct influence of each yield components themselves. For that purpose, a cause effect system (Fig.1) was formed.

Table 1: Pearson correlation analysis between grain yield and different traits in wheat

Characters	1	2	3	4	5	6	7	8	9	10	11
1. Grain protein concentration	1.000										
2. Grain protein yield	0.9847**										
3. Remobilized N	0.6511**	0.7622**									
4. Biological yield	0.7741**	0.8703**	0.9298**								
5. No. of spikes per plant	0.7079**	0.7859**	0.8600**	0.8646**							
6. No. of kernels per spike	0.8668**	0.9092**	0.8121**	0.8589**	0.8449**						
7. 1000-kernel weight	0.5024*	0.3802	-0.2054	-0.0209	0.0144	0.3009					
8. Total nitrogen at maturity	0.8720**	0.9358**	0.9306**	0.9490**	0.8621**	0.9202**	0.0953				
9. Vegetative nitrogen at maturity	0.0818	0.0755	0.6764**	0.4974*	0.4649	0.2656	-0.7189	0.4112			
10. Remobilization efficiency	0.9183**	0.9093**	0.6727**	0.7111**	0.7574**	0.8652**	0.5250*	0.8232**	0.0272		
11. Grain yield	0.8236**	0.9067**	0.9296**	0.9766**	0.8973**	0.9195**	0.0925	0.9688**	0.4517	0.8068**	1.000

** Significant at 5% level

* Significant at 1% level

Table 2: Path coefficient analysis of grain yield with different traits

Characters	1	2	3	4	5	6	7	8	9	10
1. Grain protein concentration	**-0.0207**	0.0345	-0.1638	-0.1146	0.0021	0.0177	0.0336	-0.4767	-0.0435	0.01903
2. Grain protein yield	-0.0204	**0.0350**	-0.1918	-0.1289	0.0023	0.0186	0.0254	-0.5116	0.0402	0.1884
3. Remobilized N	-0.01351	0.0267	**-0.2516**	-0.1377	0.0025	0.0166	-0.0137	-0.5088	0.3605	0.1394
4. Biological yield	-0.0161	0.0305	-0.2339	**-0.1481**	0.0026	0.0176	-0.0014	-0.05189	0.26510	0.1473
5. No. of spikes per plant	-0.0147	0.0275	-0.2164	-0.1280	**0.0029**	0.0173	0.0008	-0.4713	0.2478	0.1569
6. No. of kernels per spike	-0.0179	0.0319	-0.2044	-0.1272	0.0025	**0.0205**	0.0201	-0.5031	0.1416	0.1793
7. 1000-kernel weight	-0.0104	0.0133	0.0517	0.0031	0.0003	0.0062	**0.0670**	-0.0521	-0.3813	0.1088
8. Total nitrogen at maturity	-0.0181	0.0328	-0.2341	-0.1406	0.0026	0.0188	0.0064	**-0.5467**	0.2193	0.1706
9. Vegetative nitrogen at maturity	0.1698	0.2647	-0.1702	-0.0737	0.0013	0.0055	-0.0481	-0.2248	**0.5329**	0.0056
10. Remobilization efficiency	-0.0191	0.0319	-0.1693	-0.1053	0.0023	0.0178	0.0318	-0.4501	-0.0145	**0.2072**

(Bold values shows direct effect)

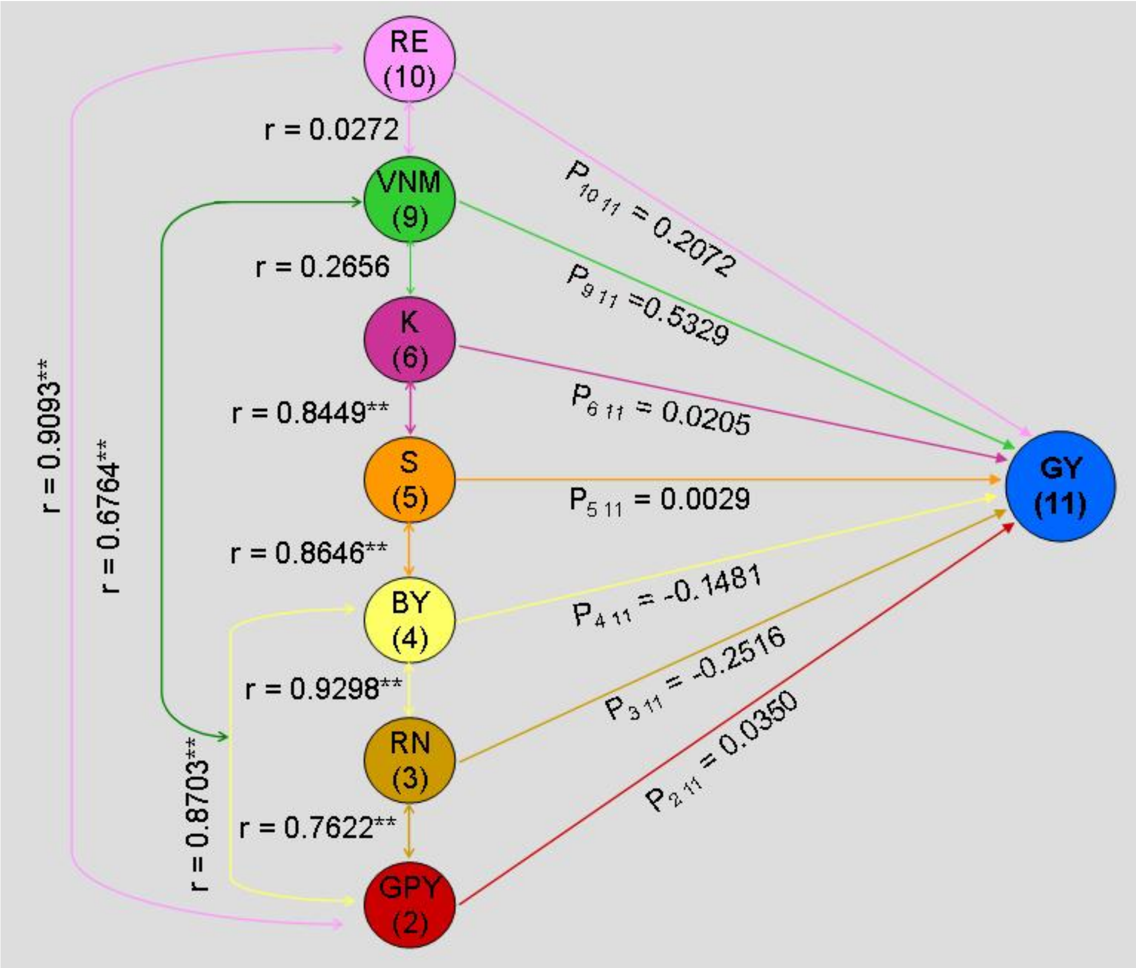

Fig. 1: Path coefficient of the direct effects of grain protein yield (GPY), remobilized nitrogen (RN), biological yield (BY), number of spikes per plant (S), number of kernels per spike (K), vegetative nitrogen at maturity (VNM) and remobilization efficiency (RE) on grain yield

(The single headed arrows indicate path correlation coefficient.
The double headed arrows indicate simple correlation coefficient.
**** Significant values).**

Path analysis of grain yield showed that the vegetative nitrogen at maturity stage had significant positive direct effect ($P_{9\ 11}$ = 0.5329) on grain yield. Vegetative nitrogen at maturity had significant positive correlation with remobilized nitrogen (r_{93} = 0.6764) and it contribute more indirectly through grain protein yield (r_{92} $P_{2\ 11}$ = 0.0267). The direct effect of grain protein yield found to be low ($P_{2\ 11}$ = 0.0350) while its correlation in correlation analysis was due to its indirect effect through remobilization efficiency ($r_{2\ 10}$ $P_{2\ 11}$ = 0.1884). Remobilized nitrogen had negative direct effect on grain yield ($P_{3\ 11}$ = -0.2516). However, its lower value of correlation in correlation analysis due to its indirect contribution through vegetative nitrogen at maturity (r_{39} $P_{3\ 11}$ = 0.3605). The direct effect of biological yield was negative directly but in correlation coefficient it shows the positive correlation. Number of spikes per plant contribute more directly ($P_{5\ 11}$ = 0.0029), its more effect on grain yield in the correlation analysis was masked by the indirect effect through vegetative nitrogen at maturity (r_{59} $P_{5\ 11}$ = 0.2478). Number of kernels per spike had direct effect on grain yield ($P_{6\ 11}$ = 0.0205) while the indirect effect through remobilization efficiency was more ($r_{6\ 10}$ $P_{6\ 11}$ = 0.1793). Remobilization efficiency contribute more directly ($P_{10\ 11}$ = 0.2072) than indirectly ($r_{10\ 5}$ $P_{10\ 11}$ = 0.0023) through number of spikes per plant (Table 2).

In order to quantitatively analyze the relationship among physiological traits and grain yield, Pearson analysis was applied (Table 3). A significant high and positive correlation of grain yield with harvest index (r = 0.9833) followed by vegetative nitrogen at milky stage (r = 0.9693). Grain yield had no correlation with total dry matter at anthesis. Correlation between accumulated dry matter with total dry matter at maturity was significantly positive (r = 0.8543). Accumulated nitrogen at anthesis was negatively correlated with total dry matter at anthesis (r = -0.0236). Nitrogen harvest index, sum of harvest index and nitrogen harvest index, total dry matter at maturity negatively correlated with total dry matter at anthesis. Correlation of maximum vegetative nitrogen significant positive with vegetative nitrogen at eight days after anthesis (r = 0.9986). Vegetative nitrogen at anthesis + 4 days positively correlated with total plant nitrogen at anthesis (r = 0.8270). Nitrogen harvest index and negative correlation with maximum vegetative nitrogen at past anthesis stage (r = -0.3951). Sum of harvest index and nitrogen harvest index had no correlation with vegetative nitrogen four days after anthesis. Correlation were especially strong for total dry matter at maturity and grain yield, accumulated dry matter and total dry matter at maturity, total dry matter at maturity and vegetative nitrogen twelve days after anthesis[8].

Table 3: Correlation analysis between grain yield and traits at different growth stages (Data pooled for wheat cultivars and nitrogen levels)

Characters	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. TDMA	1.000														
2. TPNA	0.1853														
3. VG4D	0.5014*	0.8270**													
4. VG8D	0.5528*	0.8027**	0.9921**												
5. VG12D	0.2661	0.9414**	0.9298**	0.9204**											
6. VGM	0.3595	0.9475**	0.9530**	0.9394**	0.9833**										
7. VGS	0.3253	0.9506**	0.9404**	0.9262**	0.9920**	0.9941**									
8. MXN	0.5171*	0.8281**	0.9930**	0.9986**	0.9390**	0.9534**	0.9424**								
9. HI	0.1283	0.8128**	0.8198**	0.8127**	0.9343**	0.8766**	0.9074**	0.8351**							
10. NHI	-0.8575	0.0152	-0.3985	-0.4389	-0.723	-0.1910	-0.1217	-0.3951	0.1155						
11. SUM	-0.8122	0.1402	-0.2602	-0.3005	0.0740**	-0.0501	0.0219	-0.2546	0.2664	0.9882**					
12. TDMM	-0.0029	0.8530**	0.7766**	0.7579**	0.9318**	0.8697**	0.9007**	0.7871**	0.9774**	0.2289	0.3729				
13. ACCN	-0.0236	0.6337**	0.6969**	0.7010**	0.8097**	0.7127**	0.7449**	0.7220**	0.9184**	0.1809	0.3172	0.9107**			
14.ACCDM	-0.4374	0.6435**	0.4566	0.4240	0.6846**	0.5793*	0.6304**	0.4624	0.7740**	0.5626*	0.6653**	0.8543**	0.8008**		
15. GY	0.1991	0.8897**	0.8527**	0.8472**	0.9693**	0.9311**	0.9538**	0.8701**	0.9833**	0.0625	0.2124	0.9710**	0.8596**	0.7313**	1.000

** Significant at 5% level,
* Significant at 1% level

CONCLUSION

It can be concluded that grain protein yield, remobilized nitrogen, biological yield, number of spikes per plant, number of kernels per spike, vegetative nitrogen at maturity and remobilization efficiency contribute towards yield. Vegetative nitrogen at maturity had significant direct effect on grain yield. Harvest index and total dry matter at maturity more significant positive correlation with grain yield.

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