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Research Article

Effect of Mother Plant Nutrition on Seed Quality of Wheat (*Triticum aestivum.L*) in Central Terai Region of Nepal

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Abstract

Seed quality is the major concern for future crop production which largely depends on the nutrient we applied. To evaluate the effect of different doses of nitrogen and phosphorus on yield and seed quality of wheat an experiment was conducted during 2014/15 at agronomy research block of Agriculture and Forestry University. The experiment was designed on randomized complete block experiment with four levels of Nitrogen (0, 50, 100, and 150 kg N/ha) and Phosphorus (0, 25, 50, 75 kg P_20_5/ha) Lab experiment was conducted to evaluate the germination and vigor test of the progeny seeds obtained from the mother plant. Highest grain yield (3.64t/ha) was associated with 100 kg N/ha which was statically similar with 150 kg N/ha, similarly highest grain yield (3.14t/ha) was associated with 75 kg P/ha which was at par with 50 kg P/ha and 25 kg P/ha. Highest germination percentage was associated with 150 kg N/ha (94.08) and 75 kg P/ha (93.66) Highest vigor was observed (36.5) at 100 kg N/ha which was at par with 150 kg N/ha whereas highest vigor was obtained at 50 kg P/ha (35.77) which was at par with 75 kg P/ha (35.71) Gross return, Net return and Benefit Cost ratio was highest at 100 kg N/ha which was at par with 150 kg N/ha. Similarly highest gross return (104.9 thousands) was observed at 75 kg P/ha, highest net income (54.81 thousands), and benefit cost ratio (2.105) was observed with 50 kg P/ha. Therefore for the better yield, good economic return and good seed quality application of nitrogenous fertilizers at 100 kg N/ha and phosphorus at 50 kg P/ha is useful under Chitwan condition.

Keywords: Mother plant; Seed quality; Nutrient; Germination; Vigor

Introduction

Wheat (*Triticum aestivum* L.) is the most widely cultivated food crop in the world, occupying 17% of the total cultivated land in the world (CIMMYT, 2002) It is a staple food for over 10 billion people in as many as 43 countries of the world. It provides approximately one-fifth of the total calorific input of the world's population (FAO, 2011) It is the third most important crop of Nepal after rice and maize holding an important position in terms of production and area coverage and ranks second in terms of productivity (MoAD, 2015) At present total area of cultivation in Nepal is 7, 54,474 hectares having the total production of 18,

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83,147 metric tons and productivity of 2.49t ha^{-1} (MoAD, 2015)

Wheat has a very high nutrient demand and a high productivity of a system cannot be attained and sustained unless nutrient supply is ensured (Singh, Bhunia and Chauhan, 2003; Timsina and Connor, 2001) Nutrient uptake by crops depends upon various agronomic practices like varieties, irrigation water regimes and fertilizer levels (Singh, Bhunia and Chauhan, 2003) Nitrogen is the nutrient that most often limits crop production. Cereal including rice and wheat accounted for approximately 56% of N fertilizer utilized worldwide (Shukla, Ladha, Singh, Dwivedi, Balasubramanian, Gupta and Yadav, 2004)

Nitrogen and phosphorus are two of the most important nutrients related to cereal production in the world. Not only does their availability strongly determine the rate of crop growth and thereby its final grain yield, but also their relative contribution to the grain dry matter largely determines the grain quality (Calderini, Torres-Leon and Slafer, 1995)

Nitrogen (N) is often the most deficient of all the plant nutrients. Wheat is very sensitive to insufficient nitrogen and very responsive to nitrogen fertilization. The most important roles of N in the plant is its presence in the structure of protein, component of chlorophyll, the green coloring matter of leaves which enables the plant to transfer energy from sunlight by photosynthesis. When soil available nitrogen is low, yield and protein content will be low. As more nitrogen becomes available, yield and protein rise concurrently. The yield responses to nitrogen are greater than protein responses up to certain levels of application. As nitrogen is applied beyond these levels the wheat plant will no longer use it to increase yield, but will be utilized to increase grain protein content. The effect of N on seed yield may be a consequence of N influence on photosynthesis, on the amount of photo-assimilates that are produced by the plant, on dry matter partitioning, and on organ development (Dordas and Sioulas, 2009; Dordas, Lithourgidis, Matsi, and Barbayiannis, 2008)

Phosphorus is second only to nitrogen in importance as an essential crop nutrient. It is critical for plant growth, especially in the early jointing stages and for enhancing grain yield and yield components (Römer and Schilling, 1986) Phosphorus is important in building energy for metabolism of plant growth through cellular productions such as ATP and ADP from the early stages to the end of the plant's life. It is stored as polyphosphate and in plant vacuole tissue (Maschner, 2011) It is critical in the metabolism of plants, playing a role in cellular energy transfer, respiration, and photosynthesis. It is also a structural component of the nucleic acids of genes and chromosomes and of many coenzymes, phosphoproteins and phospholipids (Khan, Lone, Ullah, Kaleem andAhmed, 2010) Phosphatic fertilizer use can help to reduce the adverse effect of drought under rainfed conditions. Most growers are aware of the importance of nitrogen in producing high yielding wheat but few recognizes the crucial role of phosphorus in increasing yields and in improving efficiency of other nutrients like nitrogen and potassium. Higher P levels increased the yield and nitrogen use efficiency (Zubillaga, Aristi and Lavado, 2002)

Materials and Methods

Farm Experiment

The experiment was conducted in the research block of Agronomy farm of Agriculture and Forestry University (AFU) Rampur, Chitwan from November 2014 to April 2015. The experimental site lies in the sub-tropical humid climatic belt of Nepal. It is characterized by three distinct seasons: rainy season (June to October), cool winter (November to February) and hot spring (March to May) During the crop cycle, average maximum and minimum temperature recorded from November to April ranged from 26.4^0c and 15.5^0C respectively. During the crop season, the maximum temperature ranged from 21.44^0c in January to 32.5^0C in April. Similarly, the minimum temperature ranged from 11.35^0C in January to 20.86^0c in April. Singh (2003) also reported that the mean daily temperature of 20-25^0C, 16-20^0C, 20-23^0C and 20-25^0C was necessary for proper germination, tillering, accelerated growth and proper grain filling of wheat crop respectively. The RH ranged between 85.37% in the month of November and 93.83% in the month January. Total rainfall during the crop period was 119.6mm with highest rainfall 43.7 mm at march. The experimental soil was sandy loam with the following characteristics in the top 20 cm profile; clay 8.9 %, silt 18.45 %, sand 72.65 % and pH 5.08. Similarly, the soil had 2.46 % SOM, 0.123 % total N, 9.04 Kg ha^{-1} available P and 70.12 Kg ha^{-1} available K which were under the low, medium, very low and low category based on rating chart (Jaishy, 2000)

The experimental field was laid out in Randomized Complete Block Design (RCBD) with three replications having 16 treatments combinations of four levels of nitrogen (0, 50, 100 and 150 kg N ha^{-1}) with four levels of phosphorous (0, 25, 50 and 75 kg N ha^{-1}) Seed sowing was done continuously with the rate of 120 kg ha^{-1} repeated at 25 cm apart with variety tillotamma having yield potential of 4.4 ton ha^{-1} recommended for late sown terai condition on November 19, 2014. Two irrigations were applied at 20 DAS and 40 DAS. Finally the well ripened crop from net plot area was harvested manually on 25th March 2015 then the mature crop was threshed, winnowed and weighed and grain yield was adjusted at 14% moisture using the formula

$$\text{Grain yield (Kg ha}^{-1}\text{)} = \frac{\text{Plot yield (kg)} * (100 - \text{grain moisture content \%}) * 10000\ \text{m2}}{(100 - 14) * \text{net plot area (m2)}}$$

Germination Test

To estimate the germination test a wet paper towel germination test was used. First of all representative sample of seed (500 g) was obtained and then paper towel was spread on a flat surface, water was used to moisten until it is thoroughly damp. Altogether 100 seeds were kept in rows on the towel again second towel was moistened placed onto the first paper towel, leaving the seeds sandwiched between the two towels. Two towels with the seeds in-between were rolled and place in a container and then to germinator that retain the moisture, relatively stable temperature *(*70^0 F) Mark the container with the date and variety of seed. After 7 days, towels were removed from the container and the seeds were carefully unwrapped so that the fragile shoots are not destroyed. Seedlings that have shoots longer than 1½ inches and at least one strong root were counted.

$$\text{Germination \%} = \frac{\text{Number of strongly germinating seeds}}{\text{Total number of seeds tested for germination}} \times 100$$

Vigor Test

Vigor test was conducted in central lab of Agriculture and Forestry University. Altogether 100 seeds from each seed lots were selected and divided to four parts each with 25 seeds. Germination paper was cut on the shape of the Petridis and dip on water to make them moist. Then seeds were placed carefully on the Petridis with the help of forceps. Then the Petridis with seeds were placed on incubator maintaining the temperature at 25^0c. Data was recorded daily until the final germination was 100%. Then vigor index (Germination Index) was calculated by following formula.

Germination index (GI) = $\sum$ (Gt/Tt),

Where, Gt= number of seeds germinated on day t and

Tt= is the number of days.

Statistical Analysis

Analysis of variance for all the parameters was done using statistical analysis through MSTAT computer software program. From the reference of Gomez and Gomez (1984) Duncan's Multiple Range Test (DMRT) was used to compare the means within the different parameters at 5% and 1 % level of significance. Microsoft Excel was used for the tabulation and simple calculation, presentation of graph for different comparisons. A simple correlation and regression analysis were run between the selected parameters using SPSS computer software program.

Results and Discussion

Yield and Harvest Index

Grain Yield

With the increase in Nitrogen doses within the range of 0 kg N ha^{-1} to 150 kg N ha^{-1} there is increase in grain yield up to 100 kg N ha^{-1} and thereafter starts to decrease with further increase in nitrogen dose to 150 kg N ha^{-1}. Highest grain yield (3.635t ha^{-1}) was obtained at 100 kg N ha^{-1} which was statically similar (3.394t ha^{-1}) with 150 kg N ha^{-1}. This was followed by 50 kg N ha^{-1} (2.192t ha^{-1}) Lowest grain yield (1.598t ha^{-1}) was obtained at 0 kg N ha^{-1}. Shah (2003) reported that 100 kg N ha^{-1} furnished at par grain yield with 150 kg N ha^{-1} and significantly higher than 50 kg N ha^{-1} in normal planting time. Increase in phosphorous doses affects the grain yield significantly within the range of 0 kg P ha^{-1} to 75 kg P ha^{-1}. Highest grain yield (3.141t ha^{-1}) was obtained at 75 kg P ha^{-1} which was statically similar (3.089t ha^{-1}) with 50 kg P ha^{-1} and 25 kg P ha^{-1} (2.768t ha^{-1}) Lowest grain yield was obtained (1.821t ha^{-1}) was obtained at 0 kg P ha^{-1}. There was no increase in yield with increase in phosphorus doses significantly between 25 kg P ha^{-1} and 75 kg P ha^{-1} because of acidic condition of the experimentation site. Availability of phosphorus is ph dependent; it is available at neutral condition. At our field condition due to acidic nature phosphorus gets bounded with acidic cations like Al^{+3}, Mg^{+2}, Mn^{+2}, Zn^{+2} Fe^{+2}, Fe^{+3}, Cu^{+2} etc so availability of phosphorus to the crop was restricted although doses was increased. Grain yield was higher; where phosphorus fertilizer was applied as compared to that where no P fertilizer was applied in case of wheat crop (Yaseen *et al*, 1998)

Relationship between grain yield and effective tillers m^{-2}

The pattern of wheat grain yield was similar to effective tillers m^{-2} indicating significantly higher correlation (r=0.5421) between these two parameters. The relation between the grain yield and effective tillers was linear with strong coefficient of determination (R^2 =0.54) This proved that the contribution from effective tillers to grain yield was 54% while the other parameters was only 46% (Fig.1).

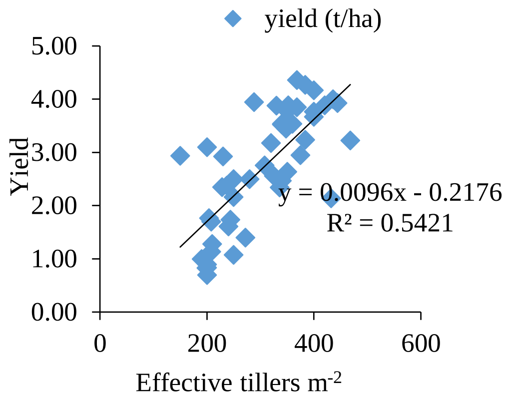

Fig. 1: Relationship between yield (t ha^{-1}) and effective tillers m^{-2}

Interaction effect of nitrogen and phosphorus doses on yield of wheat

There was no significant effect of nitrogen and phosphorus doses on yield of wheat but highest grain yield 3.92 t was observed at 100 kg N ha^{-1} and 50 kg P ha^{-1}. All the other treatments were higher than that of control. Application of nitrogen and phosphorus doses alone in higher doses dose not seems the higher yield but application of nitrogen and phosphorus doses on appropriate or balanced proportion gives the beneficial effects on grain yield (Fig. 2).

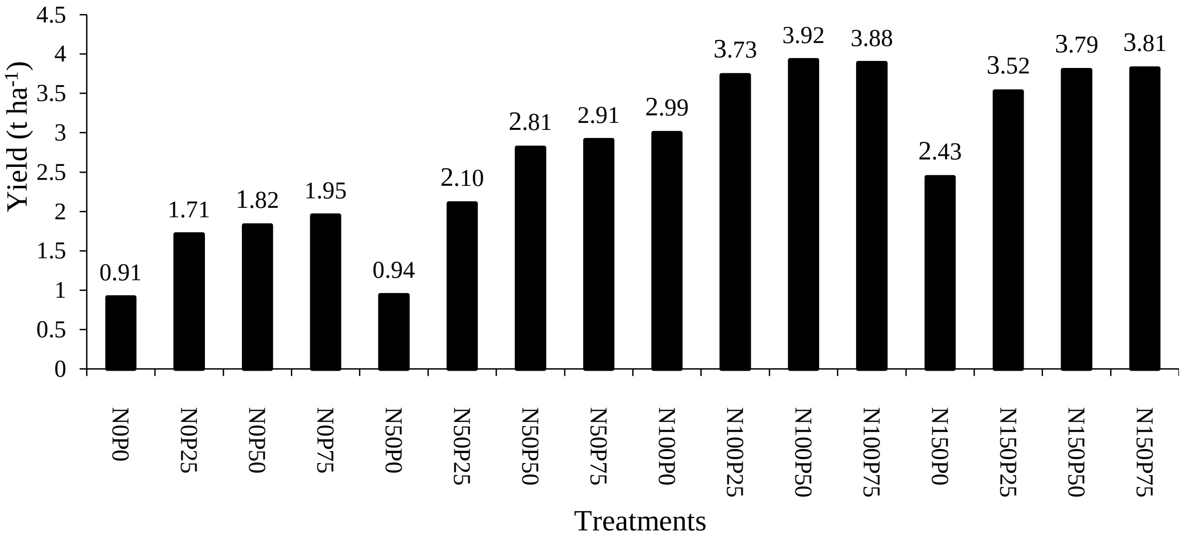

Fig. 2: Interaction effects of nitrogen and phosphorus doses on grain yield of wheat

Straw Yield

With the increment in nitrogen doses within the range of 0 kg N ha^{-1} to 150 kg N ha^{-1} there was significant increase in Straw yield. Highest straw yield (8.416t ha^{-1}) was observed at 150 kg N ha^{-1} which was statically similar with 100 kg N ha^{-1} (8.238t ha^{-1}) which was followed by 50 kg N ha^{-1} (5.198t ha^{-1}) Lowest straw yield (4.377t ha^{-1}) was observed at 0 kg N ha^{-1}. Increment in phosphorous dose from 0 to 75 kg P ha^{-1} there was significant increase in straw yield. Highest straw yield (7.148t ha^{-1}) was observed at 75 kg P ha^{-1} which was statically similar with 50 kg N ha^{-1} (7.119t ha^{-1}) and 25 Kg N ha^{-1} (6.949t ha^{-1}) Lowest straw yield was observed at 0 kg P ha^{-1} (5.011t ha^{-1}) Straw yield differed significantly from different levels of nitrogen (Table 1). Higher straw yield was obtained from nitrogen applied treatments as compared to no nitrogen applied treatments. Begun *et al* (2003) also reported that the highest straw yield was obtained from the application of 150 kg N ha^{-1} and identically followed by 120 kg N ha^{-1} but significantly different from 60 and 90 kg N ha^{-1}. The improvement of vegetative growth in terms of plant height and number of tillers per plant due to nitrogen fertilization resulted in the improvement of straw yield. The result is in agreement with that of Behera (1995) who reported that straw yield increased with increase in nitrogen rates. Khan *et al* (2010) reported that straw yield increases with increase in phosphorous levels within the range of 0 to 80 kg P ha^{-1}. Highest straw yield of (61.24g/pot) was observed at 80 kg P ha^{-1}. Straw yield was higher; where phosphorus fertilizer was applied as compared to that where no P fertilizer was applied in case of wheat crop (Yaseen *et al*, 1998).

Harvest Index

With the increase in nitrogen doses there is significant increase in harvest index up to certain dose. Harvest index goes on increasing up to 100 kg N ha^{-1} and starts to decrease thereafter. Highest harvest index (0.44) was observed at 100 kg N ha^{-1} which was statically similar with 150 kg N ha^{-1} (0.40) and 50 kg N ha^{-1} (0.40) Lowest harvest index (0.35) was observed at 0 kg N ha^{-1}. Increase in phosphorus dose effect the harvest index significantly. Highest harvest index was observed (0.44) at 75 kg P ha^{-1} which was statically par with 50 kg P ha^{-1} (0.42) and 25 kg P ha^{-1} (0.39) Lowest harvest index (0.35) was observed at 0 kg P ha^{-1}.With the increase in nitrogen dose up to 100 kg N ha^{-1} there was increase in harvest index but starts to decrease thereafter. But all the treatments were significantly higher than that of control similar results was reported by Debnath (2012) that there was increase in harvest index up to 120 kg N ha^{-1} and starts to decrease at 160 kg N ha^{-1} and all the treatments were higher than that of control. Increment in phosphorous doses leads to increase in harvest index. Aktar *et al* (2011) reported that highest harvest index (48.0%) was observed at 50 mg P/ Kg which was statically similar (49.2%) with 25 mg P/ Kg. all treatments have highest harvest index as compared to that of control (Table 1).

Grain Quality (Germination Percentage and Vigor Index)

Table 2 shows that there was insignificant effect of nitrogen and phosphorous doses on germination percentage of seed. Increase in nitrogen dose did not affect the germination percentage significantly. However, increase in nitrogen dose increase the germination percentage of the seed. Higher germination percentage (94.083%) was achieved at 150 kg N ha^{-1}, which was followed by 100 kg N ha^{-1} (92.750%), 50 kg N ha^{-1} (91.833%) Lowest germination percentage (91%) was seen with the seed lot of 0 kg N ha^{-1} fertilized plots. Phosphorous dose does not affect the germination percentage significantly but germination percentage increases with the increment on the phosphorus dose. Highest germination percentage (93.667%) was achieved at 75 kg P ha^{-1} followed by 50 kg P ha^{-1} (93.583%) and 25 kg P ha^{-1} (92.167%) Lowest germination percentage was observed at 0 kg P ha^{-1} (90.250)

Table 1: Effect of nitrogen and phosphorous levels on grain yield, straw yield, biological yield and harvest index of wheat at AFU, Rampur, Chitwan, Nepal during 2014/15

Treatments	Grain Yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index
Nitrogen Levels (kg ha^{-1})				
N_0	1.598^c	4.377^b	5.975^c	0.3583^b
N_{50}	2.192^b	5.198^b	7.389^b	0.4067^a
N_{100}	3.635^a	8.238^a	11.87^a	0.4450^a
N_{150}	3.394^a	8.416^a	11.81^a	0.4067^a
SEm(±)	0.1349	0.3249	0.4257	0.0153
$LSD_{(0.05)}$	0.3902	0.9385	1.229	0.04567
Phosphorous Level (kg ha^{-1})				
P_0	1.821^b	5.011^b	6.832^b	0.3517^b
P_{25}	2.768^a	6.949^a	9.717^a	0.3950^{ab}
P_{50}	3.089^a	7.119^a	10.21^a	0.4283^a
P_{75}	3.141^a	7.148^a	10.29^a	0.4417^a
Grand Mean	2.705	6.557	9.262	0.404
SEm(±)	0.1349	0.3249	0.4257	0.0153
$LSD_{(0.05)}$	0.3902	0.9385	1.229	0.04567
CV%	17.28%	17.16%	15.92%	13.09%

Means followed by the common letter (s) within a column are non-significantly different based on DMRT at P=0.05

Table 2: Effect of nitrogen and phosphorous levels on seed quality of wheat at AFU, Rampur, Chitwan, Nepal during 2014/15

Treatments	**Seed Quality**	
	Germination %	**Vigor index**
Nitrogen Levels (kg ha^{-1})		
N_0	91.000	32.40^b
N_{50}	91.833	33.15^b
N_{100}	92.750	36.50^a
N_{150}	94.083	35.77^a
SEm(±)	1.5050	0.8863
$LSD_{(0.05)}$	NS	2.560
Phosphorous Level (kg ha^{-1})		
P_0	90.250	32.40^b
P_{25}	92.167	33.87^{ab}
P_{50}	93.583	35.77^a
P_{75}	93.667	35.77^a
Grand mean	92.417	34.452
SEm(±)	1.5050	0.8863
$LSD_{(0.05)}$	NS	2.560
CV%	5.64%	8.91%

Means followed by the common letter (s) within a column are non-significantly different based on DMRT at P=0.05

Vigor index was significantly affected by nitrogen and phosphorous doses significantly. Nitrogen doses affect the vigor index of seed significantly. With the increase in nitrogen dose up to certain level there is increase in vigor index and then decreases then after. Vigor index increases up to 100 kg N ha^{-1} and thereafter decreased at 150 kg N ha^{-1}. Highest vigor index was observed at 100 kg N ha^{-1} (36.50) which was statically similar to the 150 kg N ha^{-1} (35.77) Lowest vigor index was observed at 0 kg N ha^{-1} (32.4) which was statically similar with 50 kg N ha^{-1} (33.15) Phosphorous doses also significantly affect the vigor index of the seed. With the increase in the phosphorous dose there was increment in the vigor index of seed up to 50 kg P ha^{-1} then after vigor index remains constant at 75 kg P ha^{-1}. Highest vigor index was observed at 50 kg P ha^{-1} (35.77) and 75 kg P ha^{-1} (35.77) This was statically similar with 25 kg P ha^{-1} (33.87) Lowest vigor index was observed at 0 kg P ha^{-1} (32.4)

Increase in nitrogen dose increase the vigor index significantly. All the treatments were significantly higher as compared to that of control similar results was also found by Warriach *et al* (2002) they reported that the seeds which showed less T_{50} were vigorous and able to germinate in less time. The individual comparison of treatment means shows significant effect of different nitrogen treatments on the T_{50} of wheat seeds in standard germination tests. The time to 50% germination of seeds of those plots, which were fertilized with 60, 120, and 180 kg N ha^{-1} was statistically less to that of control. Seeds from the plots that were fertilized with nitrogen showed less time to germinate 50 % seeds, because nitrogen application near anthesis are more efficient at increasing grain protein content (Wuest and Cassman, 1992), which may help in reducing the time to 50% germination. And phosphorus dose lead to increase in vigor index significantly within certain range this might be due to increment in protein content with the increase in phosphorus doses.

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