Research Article

Nitrogen and phosphorus fertilization of improved varieties for enhancing phenological traits of wheat

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Abstract

A field experiment was conducted at New Developmental Farm, The University of Agriculture Peshawar during rabi 2012-2013 to study the effect of N and P fertilization of improved varieties for enhancing yield and yield components of wheat varieties. Randomized Complete Block (RCB) Design with split plot arrangement having three replications was used. A sub plot size of 12 m² having ten rows of 4 m length was used. N levels (100, 125 and 150 kg ha⁻¹) and P levels (60, 90 and 120 kg ha⁻¹) were applied to the main plots and wheat varieties (Siran-2010 and Atta-Habib) were assigned to the sub plots and one control having no N and P was maintained in main plot treatment. All of the phosphorus and half of the nitrogen were applied at sowing time. The remaining N was applied at tillering stage. The results of the experiment showed that maximum days to anthesis (137), days to maturity (167), number of leaves tiller⁻¹ (6), leaf area tiller⁻¹ (117 cm²) and leaf area index (4.38) were produced by Siran-2010 while maximum plant height (98 cm) was maintained by Atta-Habib. Maximum leaf area index (4.64), were produced by 125 kg N ha⁻¹ while nitrogen application at the rate of 150 kg ha⁻¹ took maximum days to anthesis (140), days to maturity (170), number of leaves tiller⁻¹ (6), leaf area tiller⁻¹ (121 cm²), non-productive tillers m⁻² (19) and plant height (100 cm). Phosphorus application at the rate of 90 kg ha⁻¹ produced highest leaves tiller⁻¹ (6), leaf area tiller⁻¹ (121 cm²) and leaf area index (4.61). Phosphorus level of 120 kg ha⁻¹ produced maximum non-productive tillers m⁻² (19) and plant height (100 cm). Fewer days to anthesis (130) and maturity (160) were taken by control plots. It is concluded that wheat variety Siran-2010 produced better phenological traits when treated with 125 kg N ha⁻¹ and 90 kg P ha⁻¹.

Key words: Wheat (*Triticum aestivum* L.); Varieties; Nitrogen; Phosphorus; Phenological traits

Introduction

Wheat (*Triticum aestivum* L.) is the major crop among the cereal in the world and it has been playing a vital role in cultural and economic development since immemorial time. Wheat is known as the king of cereal.

It has greater significance in Pakistan in preventing food demand of the people [1, 2]. Wheat is the basic staple food of Pakistan. Wheat grain contains 12 % protein and provides about 73 % calories [3]. Wheat grains can be directly or

indirectly used as human food and its straw is used as animal feed. In Pakistan the total area under cultivation of wheat crop was 8.9 million ha, that produce 25.21 million tons of food grain with mean production of 2833 kg ha⁻¹, while in KPK wheat is cultivated over an area of about 0.72 million ha, which produce 1.11 million tones with average production of 1595 kg ha⁻¹ [4]. The leading producer of wheat in Pakistan is Punjab. In KPK, more wheat is grown in barani (61 %) than irrigated area (39 %). As compared to others developing countries wheat production in Pakistan is very low. Quality production and improvement in yield can be achieved by use of balanced nutrient application especially NPK to improved varieties of wheat crop [5]. Besides grain, wheat straw (bhossa) can also be used as roughage for livestock. In order to get highest grain yield selection of the best suited variety is very important. Cultivars are selected on the basis of various characteristics such as straw strength, grain quality and climatic adaptability etc.

Fertilizer application at proper time in balance proportion with proper method of application gave better impact on crop productivity [6]. N is essential for growth, protein synthesis, vigorous vegetative growth, chlorophyll and deep green color. Nitrogenous fertilizers are used by the farmers in much larger amount than any other fertilizer. This is because plants needed nitrogen in much larger amount than any other nutrient. Moreover our soil is deficient in this most demanding nutrient. On world basis nitrogen application is about 80 million tons [7]. To meet the increasing demand of food for increasing population of the world developing countries apply more and more fertilizers. In 2012 the world population will be more than eight million [8]. However, the fertilizer N efficiency tends to be low in this system [9].

The chemical fertilizers are the most important source of the readily available nitrogen for the crop growth. Due to the

greater availability [10] and crucial input for enhancing crop productivity [11]. N is a vital part of modern technology for enhancing crop productivity. Nitrogen is one of the major limiting elements for crop growth and development [12]. However effective N management presents greater challenge to the farmers than other fertilizer nutrients [13]. The availability of N can be enhanced by its proper time of application, and better strategies to increase crop production. Application of N improves various growth parameters like fertile tillers m⁻² [14], grain yield [15], thousands grain weight [16], more productive tillers [17]. Different nitrogen and phosphorus levels significantly effect the agronomic parameters like, plant height, grain spike, thousand grain weight and root biomass [18].

Phosphorus is essential for many physiological processes, such as storage of energy and its transfer, respiration, photosynthesis, cell division and cell enlargement etc. Phosphorous is involved in the synthesis of energy rich phosphate compound such as adenosine triphosphat (ATP) and adenosine diphosphat (ADP) which derive various biochemical reactions within the plant. Phosphorus role in plant is not limited to metabolic reactions. Phosphorus is a structural component of nucleic acid (DNA, RNA) nucleotide, phospholipids and phosphoproteins. The movement of applied phosphatic fertilizer in soil is just only 3-4 cm. Consequently, it is hardly available to the extent of 15-20% to the plant. The rest goes to waste from immediate crop being fixed in soil [19]. Phosphorus application at proper time, in optimum quantity through proper method of application is essential to increase crop production and its sustainability [20].

Phosphorous deficiency in the soil reduced crop response to nitrogen [21]. Crop required proper amount of phosphorus for the initiation of leaves and florets primomordial [22]. Whenever a plant breeder develops a new variety it is very important to find out the production

technology of that variety especially with reference to the requirement of N and P as the nutritional requirement of different variety of the same species may vary due to agro-climatic conditions of the region and their yield potential [23]. Phosphorous is an important element that impacts on zinc uptake, as by increasing phosphorous level in soil zinc uptake by plant is reduced [24]. The rate and form of N and P fertilizers can effect plant growth response to mycorrhizal inoculation. The basic role of commercial fertilizer is to enhance crop productivity but the greatest problem is the minimum use of phosphatic fertilizer in obtaining maximum crop production than nitrogenous fertilizer [25].

With reference to the important role of N and P in crop productivity, this research study was planned to evaluate the effect of various phosphorous and nitrogen levels on phenology of wheat varieties.

Materials and methods

An experiment on nitrogen and phosphorus fertilization of improved varieties for enhancing phonological traits of wheat was carried out at New Developmental Farm, The University of Agriculture, Peshawar during winter season 2012-2013. The experiment was arranged in a Randomized Complete Block Design (RCBD) with three replications in split plot arrangement. Size of the sub plots was 4 x 3 m². Seed rate of 120 kg ha⁻¹ was used. Urea and SSP fertilizers were used as N and P sources respectively. All of the P and half of the N fertilizers were applied at sowing. The rest of the N was applied at tillering stage. One control having no N and P was maintained in main plot treatment. The experiment was consisted of treatments which are nitrogen levels and phosphorus levels which are assigned to Main plots and levels are N₁ (100 kg ha⁻¹), N₂ (125 kg ha⁻¹), N₃ (150 kg ha⁻¹) where P levels are P₁ (60 kg ha⁻¹), P₂ (90 kg ha⁻¹), P₃ (120 kg ha⁻¹). Subplot included wheat varieties which are V₁(Siran-2010) and V₂ (Atta-Habib). Data was recorded on parameters which are days to anthesis, days to physiological maturity,

number of leaves tiller⁻¹, leaf area tiller⁻¹ (cm²), leaf area index, non productive tillers m⁻² and plant height (cm). In each sub plot three rows of one meter length were selected randomly to count tillers m⁻² and change accordingly to tillers m⁻². Data on days to anthesis in each sub plot was taken by counting days from sowing date to the date till 70 -80% plant produced anthesis. Days to PM were counted from sowing date to the date when 70 to 80% physiological maturity occurred in each sub plot. At anthesis stage ten tillers were randomly selected from three central rows in each sub plot. All the leaves were detached, counted and averaged to obtained number of leaf tiller⁻¹. The following formula was used to measure leaf area tiller⁻¹.

$$\text{Leaf area tiller}^{-1} (\text{cm}^2) = \frac{\text{Leaf area of all leaves}}{\text{Number of tillers}}$$

LAI at anthesis stage in each sub plot was calculated by the following formula.

$$\text{LAI} = (\text{Leaf area tiller}^{-1}) \times (\text{Number of tiller m}^{-2})$$

Tillers with un-productive spikes were counted from three randomly selected central rows in each sub plots and changed to spikes m⁻² accordingly. Spikes m⁻² was recorded by counting spikes in three randomly selected central rows in each sub plots and changed to productive tillers m⁻² accordingly. Plant height was measured by measuring height of plant by meter rod including the awns. Method applicable to the randomized complete block design (split-plot arrangement) was used for statistical analysis of the recorded data. For mean comparison in case of significant difference least significant difference (LSD) test at 5% level of significance was used [26].

Results

Days to anthesis

The effect of phosphorus and nitrogen on days to anthesis is reported in table 1. Statistical analysis of the data showed that nitrogen, phosphorus, varieties and N x P significantly ($P \leq 0.05$) affected number of days to anthesis. Increasing rates of nitrogen resulted in more days taken to anthesis. Higher days to anthesis (140)

were recorded in plots received 150 kg N ha⁻¹ and fewer days to anthesis (130) were taken by control plots. Unlike N increasing P rates resulted in decreased number of days to anthesis. More days to anthesis (138) were counted in plots received 60 kg P ha⁻¹ while minimum (130) were counted in control plots. In case of N x P interaction

N and P showed antagonistic effects i.e. increasing N rate increased days to anthesis while increasing P rate decreased days to anthesis. Between varieties maximum days to anthesis (137) were taken by Siran-2010 while less number of days to anthesis (129) was recorded for Atta-Habib.

Table 1. Days to anthesis, days to maturity, no of leaves tiller⁻¹, leaf area tiller⁻¹, leaf area index, no of productive tillers, plant height of wheat varieties as affected by nitrogen and phosphorus fertilization

Treatment	Days to anthesis	Days to maturity	No. of leaves tiller ⁻¹	Leaf area tiller ⁻¹	Leaf area index	Non-productive tiller	Plant height
N (kg ha⁻¹)							
100	132c	162c	5b	106b	3.78c	17b	93c
125	135b	165b	5b	120a	4.64a	15c	98b
150	138a	170a	6a	121a	4.48b	19a	100a
LSD (0.05)	0.84	0.84	0.19	1.79	0.112	0.762	0.919
P (kg ha⁻¹)							
60	137a	167a	5b	110c	4.11c	16b	94c
90	135b	165a	6a	121a	4.61a	16b	98b
120	134c	164c	5b	116b	4.29b	19a	100a
LSD (0.05)	0.84	0.84	0.19	1.79	0.112	0.762	0.919
Varieties							
Siran-2010	137a	167a	5	117a	4.38	16b	96b
Atta-Habib	134b	164b	5	115b	4.29	18a	98a
LSD (0.05)	0.85	0.85	ns	1.388	ns	0.859	1.4
Control	130	160	4	67	1.88	21	87
Interaction							
N x P	*	*	*	*	*	*	*

Mean values of each category followed by different letter (s) are statistically different at $P \leq 0.05$ using LSD test.

Days to physiological maturity

The impact of different levels of nitrogen and phosphorus and wheat varieties on days to maturity is reported in table 1. It was concluded from the statistical analysis of the data that various levels of N and P considerably ($P \leq 0.05$) affected number of days to maturity of wheat varieties. Only the N x P showed significant response on days to maturity while all other interactions i.e. control vs. rest x variety, N x V, P x V and N x P x V showed non significant effect on days to maturity. Increasing the rates of nitrogen resulted in increased number of days taken to maturity. Maximum days to maturity (170) was taken by the plots treated with 150 kg N ha⁻¹ and less number

of days to maturity (160) was counted in control plots. Unlike N increasing P rates resulted in decreased number of days to maturity. More days to maturity (168) were recorded for the plots treated with 60 kg P ha⁻¹ while minimum (160) were counted for control plots. Between varieties more days to maturity (167) were taken by Siran-2010 and less number of days to maturity (166) was recorded for Atta-Habib. In case of NP interaction N and P showed antagonistic effects i.e. increasing N rate increased days to maturity while increasing P rate decreased days to maturity.

Wheat varieties, N, P and N x P significantly influenced days to anthesis and maturity. Siran-2010 took more days to

anthesis and maturity while lower was taken by Atta-Habibb. The difference in days taken to anthesis and maturity may be attributed to the difference of genetic makeup of both these varieties [27]. Applications of N resulted in delaying anthesis and maturity. With increasing N levels days to anthesis and maturity also increased. Highest number of days to anthesis and maturity were counted in plots treated with 150 kg N ha⁻¹ while early flowering and maturity occurred in control plots. The late occurrence of anthesis and maturity stages might be due to vagarious and more vegetative growth in fertilized plots [28]. These results also similar with that of [29] who obtained delayed anthesis and maturity at 160 kg N ha⁻¹. Phosphorus application resulted in early flowering and ultimately early maturity. Minimum days to maturity and anthesis were recorded in plots that received 120 kg P ha⁻¹. Our results also similar with that of [30] who stated that increasing P rate facilitate earlier reproduction in wheat crop and ultimately early maturity of the crop.

Number of leaves tiller⁻¹

Statistical analysis of the data revealed that different rates of N and P significantly ($P \leq 0.05$) influenced the number of leaves tiller⁻¹ of wheat varieties (table 1). All the possible interactions except N x P showed non significant influence on the number of leaves tiller⁻¹. Both the varieties (Siran-2010 and Atta-Habib) produced same number of leaves tiller⁻¹ (5). Nitrogen rate of 150 kg ha⁻¹ produced highest number of leaves tiller⁻¹ (6). Less number of leaves tiller⁻¹ (4) was recorded in control plots. Phosphorus rate of 90 kg ha⁻¹ produced highest number of leaves tiller⁻¹ (6) while minimum (4) were recorded in control plots. In case of N and P interactions more number of leaves tillers⁻¹ (6) were produced by P levels of 90 kg P ha⁻¹ and 150 kg N ha⁻¹.

Leaf area tiller⁻¹ (cm²)

Data concerning leaf area tiller⁻¹ (cm²) of wheat varieties as influenced by N and P fertilization is given in table 1. Analysis

showed that different levels of N and P and N x P significantly ($P \leq 0.05$) influenced the leaf area tiller⁻¹. Varieties also indicated a significant response to different rates of N and P for the leaf area tiller⁻¹. Variety Siran-2010 produced more leaf area tiller⁻¹ (117 cm²) than Atta-Habib which developed (115 cm²) leaf area tiller⁻¹. A gradual increase in nitrogen resulted in a gradual increase in the leaf area tiller⁻¹. More leaf area tiller⁻¹ (121 cm²) was measured in plots received nitrogen at the level of 150 kg ha⁻¹ which is similar with 125 kg N ha⁻¹. P rate of 90 kg ha⁻¹ resulted in maximum leaf area tiller⁻¹ (121 cm²) and lowest (67 cm²) were measured in control plots. In case of N and P interactions enhancement of leaf area tiller⁻¹ increased with increasing P levels up to 90 kg ha⁻¹ at all N levels and then decreased at 125 kg P ha⁻¹.

Leaves tiller⁻¹ and Leaf area tiller⁻¹ were significantly affected by Varieties, N, P and interaction between N and P while the rest of interactions showed non significant results. Maximum number of leaves tiller⁻¹ and leaf area tiller⁻¹ were produced by Siran-2010 than Atta-Habib. Minimum number of leaves tiller⁻¹ and leaf area tiller were produced by control plots. This might be attributed to the inherent characteristics of both these varieties and other ecological factors. [31] reported similar result. Nitrogen rate of 150 kg N ha⁻¹ produced highest number of leaves tiller⁻¹ and leaf area index that was statistically similar to that produced by 125 kg N ha⁻¹. Higher nitrogen rates extended vegetative phase of the crop that result in more leaf area tiller⁻¹ and number of leaves tiller⁻¹. Our results are supported by [32] who reported maximum leaf area at 120 kg N ha⁻¹. Phosphorus application significantly affected leaves tiller⁻¹ and leaf area tiller⁻¹. Phosphorus level of 90 kg P ha⁻¹ produced maximum number of leaves tiller⁻¹ and leaf area tiller⁻¹ and minimum number of leaves and leaf area tiller⁻¹ were produced by control plots. [27] reported similar result and stated that P deficiency decrease leaf

area by producing smaller and less number of leaves tiller⁻¹.

Leaf area index

Table 1 indicated that nitrogen, phosphorus, varieties and N x P significantly ($P \leq 0.05$) affected leaf area index. Highest leaf area index (4.38) was produced by Siran-2010 and lowest leaf area index (4.29) was produced by Atta-Habib. Nitrogen rate of 150 kg ha⁻¹ resulted in highest leaf area index (4.84) while lowest (1.88) were recorded in control plots. Highest leaf area index (4.61) was produced by 90 kg P ha⁻¹, and lowest (1.88) were measured in control plots. In case of nitrogen and phosphorus interactions enhancement of leaf area index increased with increasing P levels upto 90 kg ha⁻¹ at all levels of N and then decreased at 120 kg P ha⁻¹. Wheat varieties, N, P and interaction between N and P significantly affected leaf area index the rest of the interaction showed non significant results. Siran-2010 produce highest leaf area index than Atta-Habib. The difference in genetic makeup [33] and suitability of the variety to ecological condition might the reason for highest leaf area index. Higher leaf area index (LAI) were produced by the plots treated with 125 kg N ha⁻¹ while lowest leaf area index (LAI) were recorded in control plots. Similar results were reported by [34] who got higher LAI at 120 kg N ha⁻¹. Maximum leaf area index (LAI) maintained by the plots received 90 kg P ha⁻¹ and minimum was recorded in control plots. [25] found 108 kg P ha⁻¹ to be the best level for the production of maximum LAI.

Non-productive tillers m⁻²

Data presented in table 1 revealed that N and P rates significantly ($P \leq 0.05$) influenced non productive tillers m⁻² of wheat varieties. All possible interactions beside N x P remained non significant. Wheat variety Atta-Habib produced maximum non productive tillers m⁻² (18) while minimum (16) were produced by Siran-2010. Control plots produced maximum non productive tillers m⁻² (21). Increasing N rates increased the number of

non productive tillers. More non productive tillers m⁻² (19) was recorded in plots treated by 150 kg N ha⁻¹ while lowest (15) at 125 kg N ha⁻¹. Maximum non productive tillers m⁻² (19) were produced by 125 kg P ha⁻¹ while P rate of 90 kg P ha⁻¹ produced minimum unproductive tillers m⁻² (16) that was statistically at par with 60 kg P ha⁻¹ (16). In case of NP interactions non productive tillers m⁻² increased with increasing levels of N with P. Varieties, nitrogen, phosphorus and NP interaction considerably ($P \leq 0.05$) influenced number of non-productive tillers m⁻². Highest number of non-productive tillers m⁻² was maintained by Atta-Habib while lowest by Siran-2010. The variation in non-productive tillers m⁻² may be due to the genetic variations of these two cultivars. These results are similar with that of [27]. Highest number of non-productive tillers m⁻² was maintained by control plots while minimum was recorded at 125 kg N ha⁻¹. This is supported by [35] who reported that increasing N rate decrease non-productive tillers m⁻². Highest number of non-productive tillers m⁻² were produced by control plots while lowest were found at 90 kg P ha⁻¹ that is at par with 60 kg P ha⁻¹. Higher P rates enhanced tillers survival, emergence and yield, especially for secondary tillers [36].

Plant height (cm)

Table 1 represents data regarding the effect of N, P and V on plant height. Analysis of data showed that different levels of N, P and NP interaction significantly ($P \leq 0.05$) affected plant height of wheat varieties. With each additional increment of N plant height increased. Highest plant height (100 cm) was measured in plots with nitrogen rate of 150 kg N ha⁻¹ and lower plant height (89 cm) was measured in control plots. Phosphorus rate of 120 kg ha⁻¹ produced tallest plants (100 cm) while minimum (89 cm) were recorded in control plots. Between the varieties tallest plants (98 cm) were produced by wheat variety Atta-Habib followed by Siran-2010. Regarding interactive effect of nitrogen and

phosphorus plant height increased linearly with increasing both N and P levels. Different levels of N, P and NP interaction considerably affected plant height of wheat varieties. Tallest plants were produced by Att-Habib than Siran-2010. The possible reason for this might be the difference in genetic combination of these two varieties. Considerable difference in plant height of different wheat varieties were also reported by [37]. N and P rate of 150 kg N ha⁻¹ and 120 kg P ha⁻¹ produced tallest plants. With increasing N rates plant height also increased. This is supported by [29] who got maximum plant height at N rate of 160 kg ha⁻¹. Increasing P level considerably increase plant height. These results are in agreement with [38] who stated that with increasing P rate plant height increased. Similarly [30] reported maximum plant height at 120 kg P ha⁻¹.

Conclusion and recommendation

It was concluded from the experiment that wheat variety Siran-2010 performed better than Atta-Habib in terms of phenology. Nitrogen application at the rate of 150 kg ha⁻¹ produced better phonological traits. Phosphorus application up to 90 kg ha⁻¹ showed better impact on growth and phenology. Wheat variety Siran-2010 is recommended for general cultivation due to its better growth performance. Phosphorus level of 90 kg ha⁻¹ and Nitrogen level of 150 kg ha⁻¹ is recommended for better growth and phenology of wheat.

Authors' contribution

Conceived and designed the experiments: S Anwar & Israeel, Performed the experiments: Israeel, B Iqbal, M Islam & WA Khattak, Analyzed the data: S Anwar & Israeel, Contributed reagents/ materials/ analysis tools: AA Khan, Imran, WA Shah, Ikramullah, W Akram & W Abbas, Wrote the paper: S Anwar & B Iqbal.

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