Nat. Volatiles & Essent. Oils, 2022; 9(2): 629 -643

NVEO
Natural Volatiles & Essential Oils

Effect Of Time And Methods Of Phosphorus Application On Phosphorus Use Efficiency Under Prevailing Temperature And Its Impact On Plant Growth And Yield Traits Of Wheat

Muhammad Arshad[1*] , Shakeel Ahmad Anwar[2] , Muhammad Imran[3] , Muhammad Rashid Farooq[4] , Abdul Rehman Akber[5] , Muhammad Aslam[6] , Muhammad Iqbal Shahid[7]

[1]Pesticide Quality Control Laboratory Bahawalpur-63100, Punjab, Pakistan.

[2]Pulses Research Institute, Faisalabad-38000, Punjab, Pakistan.

[3]Soil and Water Testing laboratory Rahim Yar Khan-64200, Punjab, Pakistan.

[4]Pesticide Quality Control Laboratory Kala Shah Kaku -39350, Sheikhupura, Punjab.

[5]Soil and Water Testing Laboratory, Sargodha 40100, Punjab, Pakistan.

[6]Pesticide Quality Control Laboratory Multan-59300, Punjab, Pakistan.

[7]Regional Agricultural Research Institute Bahawalpur-63100, Punjab Pakistan.

Abstract

A field experiment was conducted to study the effect of different time and methods of application of phosphatic fertilizer to wheat crop under Arid condition. Experiment was comprised of seven treatments viz: **T_1**: Boadcasting full recommended dose at seedbed preparation (115 kg ha^{-1}), **T_2**: Boadcasting 1/2 dose at seedbed preparation + 1/2 dose at booting, **T_3** : Boadcasting 1/2 dose at seedbed preparation + 1/2 dose at grain filling, **T_4**: Boadcasting 1/3rd dose at seedbed preparation + 1/3rd at booting + 1/3rd at grain filling, **T_5**: Boadcasting 1/2 dose at seedbed preparation + Fergating 1/2 dose at booting,.**T_6**: Boadcasting 1/2 dose at seedbed preparation + fergating 1/2 dose at grain filling,.**T_7**: Boadcasting 1/3rd dose at seedbed preparation + fergating 1/3rd at booting + fergating 1/3rd at grain filling. Results showed that although all the treatments tested were differing significantly from the control in all aspects studied but, application of phosphatic fertilizer broadcasted half at the time of seed bed preparation and half dose at booting stage, produced maximum grain per spike (39), number of fertile tillers m^{-2} (360.67), 1000 grains weight (52g) and grain yield (6622 kg ha^{-1}) as compared to other treatments. Maximum spikelet's and spike length were recorded in **T_6** was statistically at par with the **T_1** and **T_2**. On the basis of these results, it can be concluded that application of phosphatic fertilizer, broadcasted half dose of phosphorus out of total dose (115 kg ha^{-1}) at the time of seed bed preparation and half at the time of booting stage not only increase the plant vigor but also produced better yield under arid condition.

1. Introduction

Agriculture is still the largest sector of the economy of Pakistan in terms of labor participation and as such livelihood of the majority of the population directly or indirectly depends on it (Rebi et al.2022; Rebi et al. 2021a). However, during the last few decades, its contribution to GDP has gradually decreased to 19.3 percent however there is a lot of potential in the sector to increase its share in GDP through increased productivity utilization of latest agricultural technologies (Mahmood et al. 2021). Being the sector engaging the largest workforce and providing raw material to most manufacturing sector, its development not only contributes towards achieving poverty alleviation but can also uplift socio-economic structure of a major segment of the population (Rahman M. 2017). During FY2020, the performance of agriculture sector improved over the last year and it also performed better than other sectors. However, the challenges due to climate change, pest attacks, shortage of water etc., kept agriculture production far less than the potential (Rebi et al. 2021b) One key issue related to agriculture is that the farmers have limited direct access to the market due to which the role of middleman remains crucial. And farmers normally do not receive fair market price of their produce. In terms of potential, agriculture sector has the capacity to not only produce for the domestic population but to have surplus production for exports, which can ensure food security as well as contribute towards foreign exchange earnings.

The recent pandemic COVID-19 poses extraordinary challenges for almost all sectors of the economy of Pakistan. There was no significant impact of COVID-19 on the agriculture sector (Shammi, et al.2021). The agriculture sector grew by 2.67 percent. Positive growth of 2.90 percent in important crops was observed due to an increase in production of wheat, rice, and maize at 2.45 percent, 2.89 percent, and 6.01 percent, respectively (Sidhu et al.2018). While cotton and sugarcane posted negative growth of 6.92 percent and 0.44 percent respectively. Other crops have shown growth of 4.57 percent mainly because of an increase in the production of pulses, oilseeds, and vegetables. Cotton ginning has declined by 4.61 percent due to a decrease in the production of the cotton crops while the Livestock sector has shown a growth of 2.58 percent. The growth in forestry and Fishing remained 2.29 and 0.60 percent respectively. (Government of Pakistan 2020-21).

Wheat (Triticum aestivum L.) is the major staple food cereal crop in most of the countries and cultivated in wide range of environments (Rebi et al.2022). Its yield is greatly influenced by crop management factors. Among several crop management factors sowing method, seeding rate and selection of appropriate genotype have prime role in affecting wheat productivity (Chaudhary et al., 2016; Isidro-Sánchez et al., 2017). Wheat is the cereal of choice in many countries of the world including Pakistan. It has been playing an important role in the development of civilization since time immemorial and is rightly known as the king of cereals. Wheat grain is directly or indirectly used in human diet and the straw is consumed as animal feed. Wheat is staple food for the people and meets the major dietary requirements, supplies about 73% of the calories and protein of the average diet (Heyan, 1987). A decrease in wheat production increases the miseries of the inhabitants and severely affects the economy of the country. Wheat accounts for 8.7 percent to value addition in agriculture and 1.7 percent to GDP. Wheat crop production increased by 2.5 percent to 24.946 million tons over last year’s production of 24.349 tones. The area under cultivation increased by 1.7 percent to 8,825 thousand hectares over last year’s area (8,678 thousand hectares). The production increased due to increase in cultivated area, healthy grain formation and better crop yield. (Government of Pakistan 2020-21).

Wheat is the most important and widely cultivated crop of the entire world. It is principal food of human beings and Pakistan is one of the important wheats producing countries in the world. It is the most important staple food of about two billion people (36% of the world population). Wheat is nutritious food rich in proteins, minerals, vitamins and dietary fiber (Afzal et al., 2013; Kumar et al., 2011). Worldwide, wheat provides nearly 55% of the carbohydrates and 20% of the food calories consumed globally (Breiman and Graur, 1995). It exceeds in acreage and production every other grain crop (including rice, maize, etc.) and is therefore, the most important cereal grain crop of the world, which is cultivated over a wide range of climatic conditions and the understanding of genetics and genome organization using molecular markers is of great value for genetic and plant breeding purposes. Wheat responds well to fertilizer application with balance N:P ratio for increased wheat productivity (David et al., 2003 and Blaga et al., 1989).

Phosphorus is an essential nutrient for plant growth and development. Phosphorus also plays an important function in plant physiology. It utilizes sugar and starch and involved in transfer of energy. It strengthens the straw and increase flower formation and fruit production. When it applied in soil it becomes fixed in soil soon after its application that limits that crop growth (Mandal and Khan, 1972). Application of phosphorus enhances drought tolerance in plant. It also stimulates root growth and photosynthesis. Application of fertilizer in dry land improve yield and increases the soil water usage.

Efficient use of phosphorus fertilizers is important from both an economic viewpoint and the conservation of the world’s phosphate resources. There are several methods of P placement. Broadcasting is the most common method of application on wheat fields. However, in soils with high phosphate fixation and low levels of available P, the applications of P in bands generally increases productivity relative to broadcasting. Peterson et al. found that with winter wheat (Triticum aestivum L.) in low P soils, the effectiveness of row placement may be three to four times that of broadcasting. It has been reported that banding phosphate with wheat seed gives early availability of P, and in many cases total dry matter and grain production increased, even in soils with medium–to–high levels of available P. Banding below the seed at the time of planting has the added advantage of placing the fertilizer in immediate contact with the emerging radicle and seminal roots during seedling establishment. With medium–to–high soil P these methods were equally effective. The advantage of placement varies with soil type, application rate, pH and soil texture and the amount of precipitation in the growing season.

Phosphorus is also essential for cellular respiration, metabolism of starch and fats which has been investigated by many researchers. Appropriate and balanced fertilization on wheat and rice not only causes yield enhancement but also has good impact on phosphorus uptake by these crop plants (Rehman et al. 2006). The phosphorus that remained in the soil is important for long term phosphorus management practices. Phosphorus fertilizer recovery is low because of its conversion into unavailable forms of phosphorus that cannot be taken up by plants. Application of phosphorus fertilizer produces taller plants (Cheema et al., 2001). Applied phosphatic fertilizer can only just move 3-5 cm in soil. Resultantly, it is 15-20% available to the plants. It has been reported that the ratio of root to fertilizer contact is a major factor in nutrient availability; the more roots come in contact with soil enriched in phosphorus, the greater is the supply of phosphorus to the plant, (Barber, 1974; Yao & Barber, 1986). Keeping in view the beneficial effect of phosphorus on yield and yield attributes of wheat crop, the present study was conducted to find out the most appropriate level of phosphorus fertilizer with constant nitrogen application for obtaining maximum wheat yield under the agro-climatic conditions of KAROR with objective: (1) To determination of phosphorus use efficiency under different application method and time and its effect on wheat yield.

2. Materials and methods

2.1 Site:

The research study was conducted on sandy clay loam soil to determine the effect of time and method of phosphorus application on wheat crop at Agronomic research station, Koror Distt. Layyah, during rabi season 2020-21.

2.2 Soil analysis: Soil of experimental area was quite uniform, so a composite and representative soil sample to depth of 0-6 inch and 6-12 inch was obtained with help of soil auger, prior to sowing of crop,10 days after sowing, at booting, grain filling and after harvest. A soil sample was analyzed for its various physio-chemical properties.

2.2.1 Mechanical analysis:

Percentage of sand, silt and clay was determined by Bouyoucos hydrometer methods. Soil (40 g) was saturated overnight with 1 % sodium hexameta-phosphate solution and distilled water. Then this was isolated with electric stirrer, transferred to graduated cylinder of one liter. Silt and clay particles (%) were determined by means of Bouyoucos hydrometer. Textural class was determined by following the International Textural Triangle (Moodie et al., 1959).

2.2.2 Chemical analysis:

Soil and plant samples were analyzed according to the analytical methods described by US Salinity Lab. Staff (1954), unless otherwise mentioned.

2.2.2.1 Saturation percentage:

A portion of saturated soil paste was transferred to a tarred soil can with lid, weighed and dried to a constant weight at 105 ^{o}C, cooled and weighed again (Method 2, p. 107).

2.2.2.2 Electrical conductivity of saturated soil extracts (ECe)

Clear extract of saturated soil paste was obtained by a vacuum pump. The EC_e (dS m^{-1}) was measured by using Jenway Conductivity meter Model-4070 (Method 21a, 21c, p. 102).

2.2.2.3 pH of saturated soil paste (pHs):

Saturated paste of soil (300 g) was prepared by adding distilled water (Method 2, p. 84). The saturated paste was allowed to stand as such for overnight and pH was measured by the model HM-12 pH meter.

2.2.2.4 Organic matter:

One gram soil was mixed with 10 mL of 1.0 N potassium dichromate solution and 20 mL concentrated sulphuric acid. Then, 50 mL of distilled water and 25 mL of 0.5 N freshly prepared ferrous sulphate solution were added. The excess of ferrous sulphate was neutralized with 0.1 N solution of potassium permanganate to pink end point and at the end percentage of organic matter was determined (Moodie et al., 1959).

2.2.2.5 Available phosphorus:

Ten-gram soil was extracted with AB-DTPA solution while shaking on mechanical shaker. One mL of aliquot was taken and diluted to 2.5 mL of color developing reagent (ascorbic acid, ammonium molybdate, antimony potassium tartrate and sulphuric acid). After 30 minutes reading was recorded on ANA – 730 Spectrophotometer at a wavelength of 880 nm (US Salinity Lab. Staff (1954) (Method 16, p. 134).

2.2.2.6 Extractable potassium:

Extraction was made with the ammonium acetate and extractable K was determined by Corning Flame Photometer-410 after calibrating with K standard solution (Method 58 a, p .132).

Treatments	AV. Phosphorus				
	Pre sowing	After 10 days of sowing	Booting	Grain filling	After harvest
T_1=Broadcasting full recommended dose at seedbed preparation (115 kg ha^{-1})	14	14	14	13	9
T_2 =Broadcasting 1/2 dose at seedbed preparation + 1/2 dose at booting	15	14	15	12	7
T_3 =Broadcasting 1/2 dose at seedbed preparation + 1/2 dose at grain filling	15	15	16	12	8
T_4 =Broadcasting 1/3rd dose at seedbed preparation + 1/3rd at booting + 1/3rd at grain filling	14	14	14	12	9
T_5 =Broadcasting 1/2 dose at seedbed preparation + Fertigating 1/2 dose at booting	14	14	15	13	7
T_6 =Broadcasting 1/2 dose at seedbed preparation + fertigating 1/2 dose at grain filling	14	14	14	13	6
T_7 = Broadcasting 1/3rd dose at seedbed preparation + fertigating 1/3rd at booting + fertigating 1/3rd at grain filling	14	14	14	13	6

2.3 Experiment design and Layout:

The experiment was laid out in a randomized complete block design. The experiment was laid out in RCBD with three replications. The wheat variety Fakhar-e-Bhakkar was sown in first fortnight of November by maintaining a net plot size of 9 m × 3 m.

2.4 Treatments:

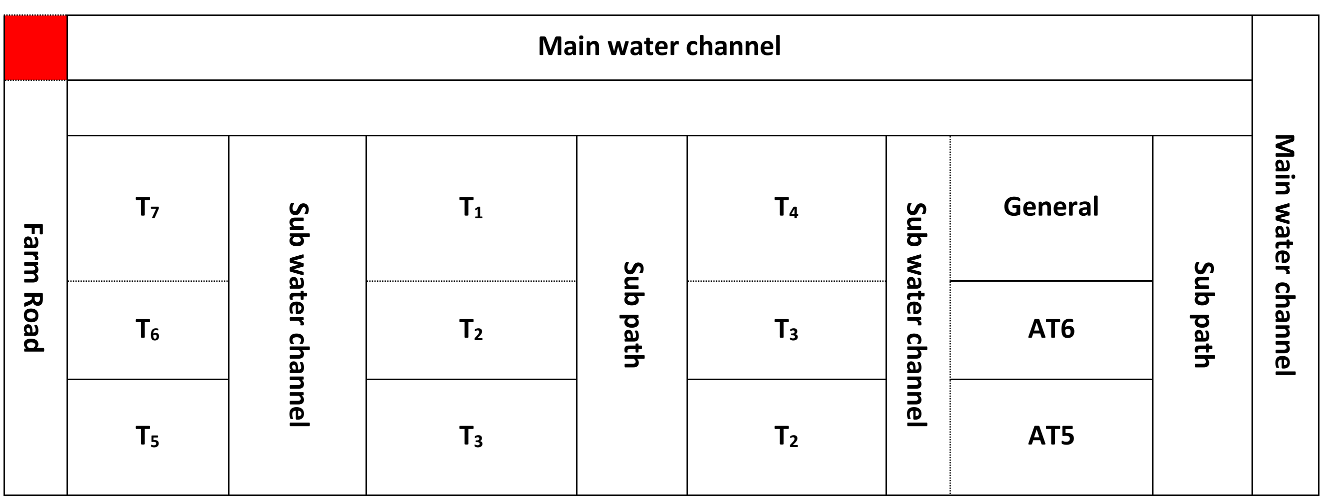
The following **treatments** were studied.

T_1 = Boadcasting full recommended dose at seedbed preparation (115 kg ha^{-1})
T_2 = Boadcasting 1/2 dose at seedbed preparation + 1/2 dose at booting
T_3 = Boadcasting 1/2 dose at seedbed preparation + 1/2 dose at grain filling
T_4 = Boadcasting 1/3rd dose at seedbed preparation + 1/3rd at booting + 1/3rd at grain filling
T_5 = Boadcasting 1/2 dose at seedbed preparation + Fergating 1/2 dose at booting
T_6 = Boadcasting 1/2 dose at seedbed preparation + fergating 1/2 dose at grain filling
T_7 = Boadcasting 1/3rd dose at seedbed preparation + fergating 1/3rd at booting + fergating 1/3rd at grain filling

2.5 Crop husbandry:

The seedbed was prepared by cultivating the field for 2-3 times with tractor- mounted cultivator each followed by planking. Fakhar-e-Bhakkar was sown in first fortnight of November by hand drill keeping row to row distance of 30 cm. A seed rate of 125 kg ha^{-1} was used. The nitrogen, phosphorus and potassium fertilizer were applied at the rate of 130-115-62 kg ha^{-1} N-K respectively. DAP as a source of P was applied as per treatment, Whole potash and 1/3rd of nitrogen was applied at the time of sowing. Remaining nitrogen was applied in three splits tillering, booting and grain filling stage. The DAP was used as source of phosphorus at sowing time while NP at booting and grain filling stage. All other agronomic practices were kept uniform, apart from treatments under study, were kept normal and uniform for all the treatments. Plant protection measures were adopted to keep crop free of weeds, insect pests and diseases. The crop was harvested on April 30.

Layout plan for the experiment:



T_4	**T_4**	**T_1**	**AT4**
T_3	**T_5**	**T_7**	**AT3**
T_2	**T_6**	**T_6**	**AT2**
T_1	**T_7**	**T_5**	**AT1**
N.E.A	**N.E.A**	**N.E.A**	**N.E.A**
R_1	**R_2**	**R_3**	**(General) 4.8 x 12.5**
	Farm Road		

2.6 Observations recorded:

Following observations were recorded during the course of study:

- ✓ Soil analysis before sowing,
- ✓ after harvesting of crop and one week after each after phosphorus application
- ✓ Plant height,
- ✓ Number of productive tillers m^{-2},
- ✓ Number of grains per spike.
- ✓ 1000-grain weight,
- ✓ Biological yield,
- ✓ Grain yield and
- ✓ Harvest index.

The procedure for recording data on these parameters was as under;

2.6.1 SOIL Analysis:

We took two samples from each plot.One from 6 inch and second from 12 inch from the same place.

2.6.2 PLANT HEIGHT (cm): Plant height data was measured at maturity by measuring the height with the help of measuring rod from the base of the plant to the tip of spike of ten representative plants in each sub plot randomly.

2.6.3 Spike length (cm):

Spikes of ten tillers were randomly selected from each sub plot and were measured with scale in cm from the basal joint of the spike till the terminal spike excluding the awns.

2.6.4 Number of spikelet's/spikes:

Ten spikes were selected randomly from each sub plot and number of spikelet's were counted on each spike manually.

2.6.5 Number of Grains Spike^{-1}:

Ten spikes were selected randomly from each plot and grains spike-1 were counted. The values were averaged to obtain the mean value.

2.6.6 Number of productive tillers m^{-2}:

Data from one square meter with the help of quadrate was harvested with the help of sickle from each sub plot. After that number of tillers were counted manually from the harvested data of each plot.

2.6.7 1000-grain weight:

Thousand grains were counted from threshed clean grains of each treatment and then were counted manually 1000-grain weight of each treatment.

2.6.8 Biological yield (kg/ha):

For recording biological yield meter per square data of each sub plot were harvested at their maturity and the whole material was sun dried. After drying it was weighed by spring balance and was converted to (kg/ha).

2.6.9 Grain yield (kg/ha):
For recording grain yield data, meter per square with the help of quadrat were harvested from each sub plot with the help of sickle and were sun dried. After threshing the grains were weighed with the help of electronic balance and converted into kg/ha).

2.6.10 Harvest index:
Harvest index is calculated by dividing grain yield over biological yield and multiplied by 100. The formula is as follows:

HI= grain yield/biological yield*100

2.6.11 Statistical Analysis:

The data collected on all parameters were analyzed statistically by using Fisher's Analysis of Variance Technique (Steel et al., 1997). Least Significant Difference (LSD) test, at 5% probability level, was applied to compare the treatment's means (Gomez and Gomez, 1999).

Results and discussion

1- Grains per spike:

The data presented in table 1. showed that the maximum grain per spike was attained (39) where crop was fertilized with half dose of phosphorus application out of total recommended phosphorus (115 kg ha^{-1}) was applied at the time of seed bed preparation and half dose at booting stage which was statistically at par with control treatment when full recommended dose of phosphorus (115 kg ha^{-1}) was applied at seed bed preparation and produce grain per spike (38) and followed by T3,T4,T5 and T7 (34) which showed non significant difference with rest of treatments. The minimum grain per spike of (30) was recorded in treatment were half dose of phosphorus was broadcasted at seed bed preparation and dose of phosphorus was fertigated at grain filling.

The current study repoeted that the increase in grain yield of wheat can be attributed to the increase in number of grains per spike. Several researchers also supported this fact. Phosphatic fertilizer broadcasted with seed during the sowing of crop and applied at booting stage, significantly enhanced the number of grains per spike a that ultimately increased the grain yield of crop.

Treatments	Grains per spike	Tillers/ m^2	Number of spikelet's	Plant height (cm)	Spike length (cm)	1000 grain weight	Grain yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index
T^1	38 a	381 a	17 bc	106 a	11 a	45 c	5709 d	25000 a	23 c
T^2	39 a	360 ab	18 ab	103 ab	11 a	52 a	6622 a	20000 ab	33 abc
T^3	34 ab	347 ab	17 abc	105 ab	11 a	49 ab	5944 cd	20000 ab	29 bc
T^4	34 ab	337 b	16 c	102 b	11 a	47 bc	6318 b	15000 b	42 ab
T^5	34 ab	364 ab	17 bc	102 b	10 a	46 bc	6100 bc	20067 ab	31 abc

T^6	30 b	359 ab	18 a	102 b	11 a	46 bc	5909 cd	20733 ab	33 abc
T^7	34 ab	336 b	17 abc	104 ab	11 a	46 bc	6094 bc	15000 b	44 a
$LSD_{5\%}$	6.8	36.005	1.0513	3.5896	0.7601	4.0000	264.28	6144.0	13.418

2- Tillers/m^2:

The data presented in table 1. showed that the maximum tillers were attained (381) where crop was fertilized with full recommended dose of phosphorus (115 kg ha^{-1}) was applied at the time of seed bed preparation which was followed by T5 (364) where half dose of phosphorus was applied at seed bed preparation and half dose of phosphorus was fertigated at booting stage which was followed by T2, T3 and T6 which showed non significant difference with rest of all treatments. The minimum tillers of (336) was recorded in treatment were one third dose of phosphorus was broadcasted at seed bed preparation,one third dose of phosphorus was fertigated at booting stage and one third dose of phosphorus was fertigated at grain filling stage which was statistically at par with T4.

The current study shows that phosphorus applied at the time of sowing produce greater tillers. The result is in line with finding of Maqbool et al. (2012) who reported that mixed P with seed at the time of seed bed preparation produced higher number of tillers because the P mixed with seed has an advantage of placing the fertilizer in immediate contact with the emerging radicle and seminal roots during seedling establishment.

3- Number of spikelet's:

The data presented in table 1. showed that the maximum number of spikelet's were attained (18.33) where crop was fertilized with half dose of phosphorus was broadcasted at the time of seed bed preparation and half dose of phosphorus was fertigated at grain filling stage which was statistically at par where half dose of phosphorus was broadcasted at seed bed preparation and half dose of phosphorus booting stage which produced spikelet's average of (17.66) which showed non significant difference with rest of all treatments. The minimum number of spikeletes of (16.33) was recorded in treatment were one third dose of phosphorus was broadcasted at seed bed preparation,one third dose of phosphorus was broadcasted at booting stage and one third dose of phosphorus was broadcasted at grain filling stage.

4- Plant height:

The data presented in table 1. showed that the maximum plant height was attained (106.33) where crop was fertilized with full recommended dose of phosphorus (115 kg ha^{-1}) was applied at the time of seed bed preparation which was statistically at par with T3 (105.33) where half dose of phosphorus was broadcasted at seed bed preparation and half dose of phosphorus was broadcasted at grain filling stage which was followed by T2, and T7 which showed non significant difference with rest of all treatments. The minimum plant height of (102.33) was recorded in treatment were one third dose of phosphorus was broadcasted at seed bed preparation,one third dose of phosphorus was broadcasted at booting stage and one third dose of phosphorus was broadcasted at grain filling stage which was followed by T4 and T5.

The current study shows that phosphorus applied at the time of sowing produce greater plant height. The result is in line with finding of Maqbool et al. (2012) who reported that mixed P with seed at the time of seed bed preparation produced greater plant height because the P mixed with seed has an advantage of placing the fertilizer in immediate contact with the emerging radicle and seminal roots during seedling establishment.

5- Spike length:

The table 1 showed that application of phosphorus at any stage e.g., at seed bed preparation, at booting stage and at grain filling stage does not show any significance difference in the spike length of plant. In treatment where half dose of phosphorus was broadcasted at the time of seed bed preparation and half dose of phosphorus was fertigated at grain filling stage show little greater spike length of plant then the rest of all the treatments. All the spike length of each treatment were statistically at par with each other and show non significance difference with each other.

Our results are in line with (Cheema et al.2001) which reported that there was an increase in plant height and spike length with the application of phosphorus fertilizers. The current study also showed that with the application of phosphorus spike length increases.

6- 1000 grain weight:

The data recorded in the table: 6 showed that maximum 1000 grain weight was attained in treatment T_2 where half dose of phosphorus out of total phosphorus (115 kg ha^{-1}) was broadcasted at seed bed preparation and half dose was applied at booting stage which produced 1000 grain weight of (52), followed by T3 where half dose of phosphorus was broadcasted at seed bed preparation and half dose of phosphorus was applied at grain filling stage and produced 1000 grain weight of (49.33). In treatment T_4, T_5, T_6 and T_7 are statistically at par with each other. The minimum 1000 grain weight was recorded in control treatment where full recommended dose of phosphorus was broadcasted at the time of seed bed preparation and produced grain weight of (45).

Present studies indicate that the increase in grain yield of wheat can be attributed to the increase in number of grains per spike and weight of 1000grains. Several researchers also supported this fact. Phosphatic fertilizer applied at booting stage, mixed with seed during the sowing of crop significantly enhanced the weight of 1000-grains that ultimately increased the grain yield of crop.

Results of current study in line with the findings of Latif et al. (1994) who also narrated that solution of phosphate fertilizer applied along with the first irrigation produced wheat grain yield equivalent to P mixing with seed during sowing or top dressing after plant emergence during the first irrigation.

7- Grain yield:

The data presented in table 1. showed that the maximum grain yield was attained (6622 kg ha^{-1}) crop was fertilized with half dose of phosphorus application out of total recommended phosphorus (115 kg ha^{-1}) was applied at the time of seed bed preparation and half dose at booting stage followed by treatment when 1/3rd dose of phosporus broadcasted at the time of seedbed preparation, second 1/3rd at booting and final 1/3rd dose at grain filling stage and produced grain yield of 6318 kg ha^{-1} which showed non significant difference with rest of all treatments. The minimum grain yield of 5709 kg ha-1 was recorded in control plot where full recommnded dose of phosphorus was applied at the time of seed bed preparation.

The results are in line with (Alessi and Power, 1980). It has been also reported that phosphate fertilizer with wheat seed gives early availability of P, and in many cases total dry matter and grain production increased, even in soils with medium to high levels of available P. The current study also reported that application of phosphorus during seed bed prepartion give maximum yield.

8- Biological yield (kg ha^{-1}):

The data presented in table 1. Showed that maximum biological yield was attained in control treatment where full recommended dose of phosphorus (115 kg ha^{-1}) was broadcasted at the time of seed bed preparation which produced biological yield of (25000 kg ha^{-1}) followed by T_2 and T_3 where half dose of phosphorus out of total was broadcasted at seed bed preparation and half dose of phosphorus was applied at booting stage which produced biological yield of (20000 kg ha^{-1}) which was statistically at par with T_5 and T_6. The minimum data was recorded in T_4 and T_7 where one third dose of phosphorus out of total was broadcasted and one third dose of phosphorus was fertigated and broadcasted at booting and grain filling stage which produced biological yield of (15000 kg ha^{-1}).

Our results are in line with Turk and Tawaha (2001) and Ahadiyat et al., (2014) who reported higher grain and straw yield with phosphorus application. The current showed the same result that application of full dose of phosphorus at the time of seed bed preparation increases the biological yield. Dividing the phosphorus application at different stages decreases the biological yield.

9. Harvest index:

The data presented in the table 1. Showed that maximum harvest index was attained in T_7 where one third dose of phosphorus out of total (115 kg ha^{-1}) was broadcasted at seed bed preparation, one third dose of phosphorus was fertigated at booting stage and one third dose of phosphorus was fertigated at grain filling stage produced harvest index of (44 %). Which was followed by T_4 where one third dose of phosphorus was broadcasted at the time of seed bed preparation, one third at booting and one third at grain filling stage which produced harvest index of (42%). The data also showed that T_2, T_3 and T_6 was statistically at par with each other. The minimum harvest index was attained in control treatment where full recommended dose (115 kg ha^{-1}) was broadcasted at the time of seed bed preparation and produced harvest index of (23%). The result is line with (Latif et al., 1997). They reported that P-uptake by wheat was also higher when phosphorus was applied by fertigation as compared to soil mixing. The current study also showed that fertigated phosphorus give maximum harvest index as compared to broadcasted.

Conclusion:

It is obvious from the current study that maximum phosphorus was taken when half dose of phosphorus out of total phosphorus (115 kg ha^{-1}) was broadcasted at the time of seed bed preparation and half dose at the of booting stage which increases grains per spike, number of tillers m^{-2} which were higher than the all the treatment except control treatment, number of spikelet's, spike length, 1000 grain weight also increases and ultimately all the increases, increase the overall grain yield of plant. It can be concluded that half application of phosphatic fertilizer broadcasted at the time of seed bed preparation and half dose at booting stage not only increase the plant vigor but also produced better yield under arid condition.

References

Afzal, S., A. Shehzad, M. A. Randhawa, A. Asghar, M. Shoaib and M. A. Jahangir. 2013. Health Benefits and Importance of Utilizing Wheat and Rye. Pak. J. Food Sci., 23: 212-22.

Ahadiyat, Y.R. P. Hidayat and U. Susanto. 2014. Drought tolerance, phosphorus efficiency and yield characters of upland rice lines. Emir. Journal of Food and Agriculture 26(1): 25-34.

Alessi, J. and J.F. Power. 1980. Effects of banded and residual fertilizer phosphorus on dryland spring wheat yield in the northern plain. Soil Sci. Soc. Am. J. 44: 792–796.

Ashraf, M.M. 1987. Optimum NP requirement for new wheat cultivars. M.Sc. (Hons.) Agri. Thesis, Agron. Dept. U. A., Faisalabad.

Barber, S.A. 1974. A program for increasing the efficiency of fertilizer. Fertilizer Sol., 18: 224-225.

Blaga, G .V. Micalus and T. Lechintan.1989. Investigations on the effect of organic and minerals fertilizers on yield of maize and oats grown at sterile waste dumps. Buletiunul Institutului Agronomic Cluj Napoca Seria Agric. Romania, 43: 5-9 (Field Crop Absts, 43 (11): 7715:1990).

Chauhdary, J.N., U.D. Khan, S.H.H. Shah, M.A. Shahid and M. Arsalan. 2016. Effect of sowing methods and seed rates on wheat yield and water productivity. Qual. Assur. Saf. Crops Foods. 8(2): 267-272.

Cheema, M.A., M.A. Malik, A. Hussain, S.H. Shah and S.M.A Basra. 2001. Effects of time and rate of nitrogen and phosphorus application on the growth and the seed and oil yields of canola (Brassica napus L.). J. Agron. Crop Sci., 186: 103-110.

Cheema, M.A., M.A. Malik, A. Hussain, S.H. Shah and S.M.A Basra. 2001. Effects of time and rate of nitrogen and phosphorus application on the growth and the seed and oil yields of canola (Brassica napus L.). J. Agron. Crop Sci.,186: 103-110.

David, H., A. Speirs, P. Flavel, K. Motley and C. Dyson. 2003. Phosphorus-yield in wheat, canola and field peas grown at different soil P and levels. Austr. J. Agron. 20: 1-6.

Gomez, K.A. and A.A. Gomez, 1999. Statistical procedure for agricultural research. John Wiley and Sons, New York, USA.

Heyan, E. G. 1987. Wheat and wheat improvement. 2nd ed. Madison, Wisconsin, USA.

http://www.finance.gov.pk/survey_1920.html.

https://sundoc.bibliothek.uni-halle.de/diss-online/04/04H184/t2.pdf.

Isidro-Sánchez, J., B. Perry, A.K. Singh, H. Wang, R.M. DePauw, C.J. Pozniak, B.L. Beres, E.N. Johnson and R.D. Cuthbert. 2017. Effects of seeding rate on durum crop production and physiological responses. Agron. J. 109(5): 1981-1990.

Kumar, P., R. Yadava, B. Gollen, S. Kumar, R. K. Verma and S. Yadav. 2011. Nutritional contents and medicinal properties of wheat: a review. Life Sci. Medicine Res., 22: 1-10.

Latif, A., S.M. Alam, A. Hamid and Z. Iqbal. 1997. Relative efficiency of phosphorus applied through broadcast incorporation, top dressing and fertigation to crops. Pak J. Soil Sci. 13: 15-18.

Latif, A., S.M. Alam, Z. Iqbal and A. Hamid. 1994. Effect of rate, time and method of application of phosphorus fertilizer on wheat crop. Proceedings 4th National Congress of Soil Science, Islamabad, pp. 299-303.

Mahmood, A., Rafique, M. A., Yaseen, G., Zaib, M., Arif, M., Naseem, M., ... & Rebi, A. (2021). Effect Of Global Change and Possible Ways To Reduce Its Adverse Impact On Agriculture In The Overall World: A Review. NVEO, 16252-16278.

Mandal, L.N. and S.K. Khan. 1972. Release of phosphorus from insoluble phosphatic materials in acidic low land rice soils. Journal of Indian Society of Soil Science 20: 19-25.

Maqbool, M.M., M. Ahmad, A. Ali, R. Mehmood, M. Ahmad and M. Sarwar. 2012. Optimizing the method and source of phosphatic nutrition for wheat (Triticum astivum L.) under agroclimate of Gera Ghazi Khan, Pakistan. Pak. J. Nutr. 11: 787-792.

Moodie, R.E., R.W. Smith and R.A. MacGreery. 1959. Laboratory Manual of Soil Fertility. State College Washington, Mimeograph, Pullman, WA, USA. p.175.

Peterson, G.A., P.H. Sander, P.H. Grabouski, M.L. Hooker. A New Look at Row and Broadcast Phosphate Recommendations for Winter Wheat. Agron. J. 73: 13–17, 1981.

Rahman, M. (2017). Role of agriculture in Bangladesh economy: uncovering the problems and challenges. Int J Bus Manag Inv, 6(7).

Rebi, A. Kashif, H. M., Chaudhry, U. F., Zaib, M., Shahid, M. Z., Safdar, M., ... & Afzal, A. (2022). Phosphorus Availability In Soil And Uptake By Maize From Rock Phosphate Inoculated With PGPR: A Review. NVEO, 341-355.

Rebi, A., Ahmed, M. I., Saeed, A., Rehman, T., Mansha, M. N., Nawaz, S., ... & Naz, M. (2021). Soil ecology and possible and possible effects of soil texture microbial assisted Co2 sequestration. NVEO, 7458-7480b.

Rebi, A., Rehman, T., Wahaj, M., Raza, H. A., Usman, M., Gul, N., ... & Ahmed, M. I. (2021). Impact of Sewage Water on Human Health and Agricultral Land: A Review. Annal Rom Soc Cell Bio, 25: 1366-1376a.

Shammi, M., Bodrud-Doza, M., Islam, A. R. M., & Rahman, M. (2021). Strategic assessment of COVID-19 pandemic in Bangladesh: comparative lockdown scenario analysis, public perception, and management for sustainability. Environ Develop Sustain, 23: 6148-6191.

Sidhu, M. S., & Singh, V. P. (2018). Fifty years of Punjab Agriculture: An Appraisal. Productivity, 59(1).

Steel, R.G.D., J.H. Torrie and D.A. Dicky. 1997. Principles and Procedures of Statistics, A biological approach. 3rd Ed. McGraw Hill, Inc. Book Co. N.Y. (U.S.A.). pp. 352-358.

Turk, M.A. and A.M. Tawaha. 2002. Impact of seedling rate, seeding date, rate and method of phosphorus application in faba bean (Vicia faba L. Minor) in the absence of moisture stress. Biotechnology and Agronomic Society and Environment 6: 171-178.

Yao, J. and Barber S.A. 1986. Effect of phosphorus rate placed in different soil volumes of phosphorus uptake and growth of wheat. Comm. Soil Sci. Plant Anal., 17: 819-827.