EFFECT OF NITROGEN, PHOSPHORUS AND FARMYARD MANURE LEVELS ON YIELD, YIELD COMPONENTS AND SOME MORPHOLOGICAL TRAITS OF POTATO *(SOLANUM TUBEROSUM* L.)

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ABSTRACT: The present investigation was carried out to evaluate the effect of inorganic fertilizer (Nitrogen and Phosphorus), and farmyard manure on morpho-physiological parameters of potato. Randomized Complete Block Design with five treatments (T1: Urea; T2: Nitrophos; T3: Di-ammonium Phosphate (DAP); T4: farmyard manure (FYM) and T5: Control Treatment) were used. Each treatment is replicated 4 times. The result showed that fertilizers significantly affect the number of compound leaves, flowers, number and length of lateral stem plant $^{-1}$ and length, girth and weight of potato tubers. The plant treated with DAP showed a plant height of 83.49 cm while the control treatment showed the lowest plant height (59.33 cm). The plant treated with farmyard manure showed a stem girth of 5.25 cm, while the lowest stem girth was observed in control. The highest tuber weight (100.42 g) was noted under the treatment of Urea, followed by Nitrophos (98.80 g), DAP (78.97 g) and farmyard manure (75.97 g). Total tuber weight per plant 622.95g, 549.45 g, 423.41 g, and 401.74 g under Urea, Nitrophos, DAP and farmyard manure were observed respectively. In addition, the highest Girth of potato tuber (14.44 cm) was observed at T2 Treatment (Nitrophas). It is concluded that using inorganic fertilizers and farmyard manure would be beneficial for achieving sustainable yields.

Key words: Potato, Yield, Urea, Nitrophos, Di-ammonium Phosphate, Farmyard manure.

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INTRODUCTION

The potato crop (*Solanum tuberosum* L.) belongs to family Solanaceae and is an important starchy food crop. It plays an important role in human nutrition. Potato ranked fourth among the cash crops of Pakistan and was grown on an area of 234400 hectares and 4.45 million tons total production in 2020. The production of potatoes increased by almost 50% with 7.74 million tons in 2021-22. The major potato-production provinces are Punjab (94%), Balochistan (1%), Sind (0.33%) and Khyber Pakhtunkhwa (5.17%). Pakistan stands 12th in potato export and represents 1.6% of world potato exports (Hassan *et al.,* 2021). The production of potatoes in Pakistan is progressively increasing but depends mainly on soil fertility and agricultural practices. The seeds or tubers of the potato plant are used for cultivation. The root system of potatoes is poor as compared to other crops therefore superior soil form is essential for potato growth (Maynard and Hochmuth 2006). The potato is growing as an autumn crop (September 15 to November 15), spring crop (January 01 to February 15) and a summer crop from April 01 to June 30. The growth of potatoes requires good fertile soil with having proper drainage system. Fertilizers play pivotal role in the growth and yield of potato. Nitrogen and Phosphorus fertilizers are essential nutrients for the growth of potato and balance the vegetative and reproductive growth of plants (Errebhi *et al.,* 1998; Leytem and Westermann, 2005). The protein and dry matter contents increase due to the balanced amount of these nutrients in the soil (White *et al*., 2007; Zelalem *et al*., 2009; Li *et al*., 2022). The plant height, average tuber weight, leaf area and numbers are increased due to N and P fertilizers (Kandil *et al.,* 2011). The organic matter in the soil maintains the soil quality and improve crop production (Pedra *et al.,* 2007). The soil fertility is restored and maintained through composts. The use of nitrogen fertilizers and farmyard manures improve the growth and yield of potato (Zelalem *et al.,* 2009). The deficiency of essential nutrients dramatically affects the yield. Similarly, mineral fertilizers play a pivotal role in the availability and sharing of nutrients in the soil and its availability for the plant (PáŽSLEA and Florin, 2012). Nitrogen improves the vegetative growth and morphological characteristics of potato (Kandil *et al.,* 2011). Urea contains about 46% nitrogen and is used in the form of nitrogen fertilizers (Sanz-Cobena *et al.,* 2011). NPK plays an important role in the yield and quality of potato tuber (Al-Moshileh *et al.,* 2005). The

local community at Dir Kohistan are utilizing different fertilizers without considering the requirement of the plant and soil. The present study aims to determine the effect of different doses of fertilizers (DAP, Nitrophos, Urea and Farmyard manure) on yield, yield components and some morphological traits of potatoes and to recommend a suitable combination of nitrogen, phosphorous fertilizers and organic wastes for the best yield as well as other morphological traits of potato crop.

MATERIALS AND METHODS

The present investigation was carried out in Spring 2018. A fertile land was selected for field experiment at Doagdara, District Dir Upper, Khyber Pakhtunkhwa, Pakistan. Doagdara is located at 35° 21′ 59.8″ N and 71° 57′37.1″ E having 490 ft elevation from the sea level. It is surrounded by District Swat in the East, Chitral on the North, Makakand Agency on the South and Bajaur on the West. The soil texture was sandy loam with 220 ml water/kg of water holding capacity and pH 6.8. The soil consist of Sand (54%), Silt (44%), Lime (2.5%), Organic matter (1.6%) and Clay (1.6%). The potato cultivar "Altamash" was selected for the experiment. The land was prepared by plowing and leveling the field. After field preparation, potato sowing was done in furrows with 15 cm distance between the plants and 30 cm row to row distance respectively. The potatoes were sowed in five replicates. The agronomic practives were properly observed during the experiment. RCBD design (Randomized Complete Block Design) was used with five treatments (T1: Urea; T2: Nitrophos; T3: Di Ammonium Phosphate (DAP); T4: Farmyard manure; T5: Control) and 4 replicates in 20 experimental units through random cards/number. The Urea, Nitrophos, DAP and Farmyard manure were applied in a ration of 15kg/hectares. In the initial growth stages adequate irrigation was done.

The organic fertilizers were used as farmyard manure. After the plantation had been established for 20 days, urea was applied. Before sowing, farmyard manure and nitrophos DAP were applied. Following the application of fertilizer, the weeds were removed from the field. Before harvesting, three rounds of fungicide spray (Acrobat MZ 90/600 WP) were applied for control of downy mildew, early and late blight diseases. After four weeks of plantation, the first dose of fungicide spray was applied in order to avoid fungal attack. The 2nd and 3rd doze were applied after observation of late blight symptoms with an interval of seven days. The fungicide was used @ 2g/liter of water. Five plants were randomly selected each treatment and the vegetative characters (Plant height, leaf area and stem diameter) and yield parameters (number and weight of tubers/ plant) were recorded. The potatoes were harvested when the foliage become yellowish or dry. The potato tubers were carefully collected from the soil and stored in well ventilated, cooled and dark conditions.

RESULTS AND DISCUSSION

The fertilizers (urea, DAP, nitrophos and farmyard manure) showed positive growth promoting effects on the growth and morphological traits of potatoes (Table 1).

Effect of treatments on plant height and Stem girth of potato: The effect of different treatments (Urea, Nitrophos, DAP and Farmyard manure) on plant height and stem girth is presented in Table 1. Different treatments showed significant differences among the treatments. T3 treatment significantly increases the plant height compared to the rest of the treatments. The plant treated with DAP showed a plant height of 83.49 cm. The control treatment showed lowest plant height (59.33 cm). The plant treated with urea and nitrophos showed plant height of 76.08 cm and 74.33 cm respectively. The different fertilizers also have significant effects on the girth of the main stem. The plant treated with farmyard manure showed a stem girth of 5.25 cm, while the lowest stem girth was observed in the control. Farmyard manure contains essential nutrients and plays a consequential role in the solubility and supply of essential nutrients (White *et al.*, 2007). The plant height, leaf area and carbohydrate contents of potato also improve due to increase in potassium sulfate rate (Al-Moshileh *et al.*, 2005). The beneficial effects of commonly used fertilizers like Urea, DAP (Diammonium phosphate), Nitrophos and Urea on different growth parameters like plant height, vegetative characters and yield of plants were also reported previously (Patel *et al*., 2000; Birch *et al*., 2012). The fertilizers provide nitrogen to the plant and promote its growth and development (Birch *et al*., 2012). Nitrophos contain nitrogen and phosphorus and help in promoting physiological processes like water uptake and root development and thus contribute to increasing the plant height and stem girth (Patel *et al*., 2000). Diammonium phosphate (DAP) is an important source of phosphorus and helps in the development of root growth and improves the update of nutrients from the soil (White *et al*., 2007). The farmyard manures are actually organic manure or compost and are mostly derived from plant residues and animal wastes. It provides a range of nutrients and improves soil structure texture and helps in improving microbial activities. When incorporated into the soil before planting potatoes, farmyard manure enhances overall soil fertility and nutrient availability, leading to healthier plant growth. The direct effect of chemical fertilizers on plant height and stem girth has not been observed, however, the improved soil conditions facilitated by farmyard manure can indirectly contribute

to better growth and development of potato plants (Priyanka *et al.*, 2020).

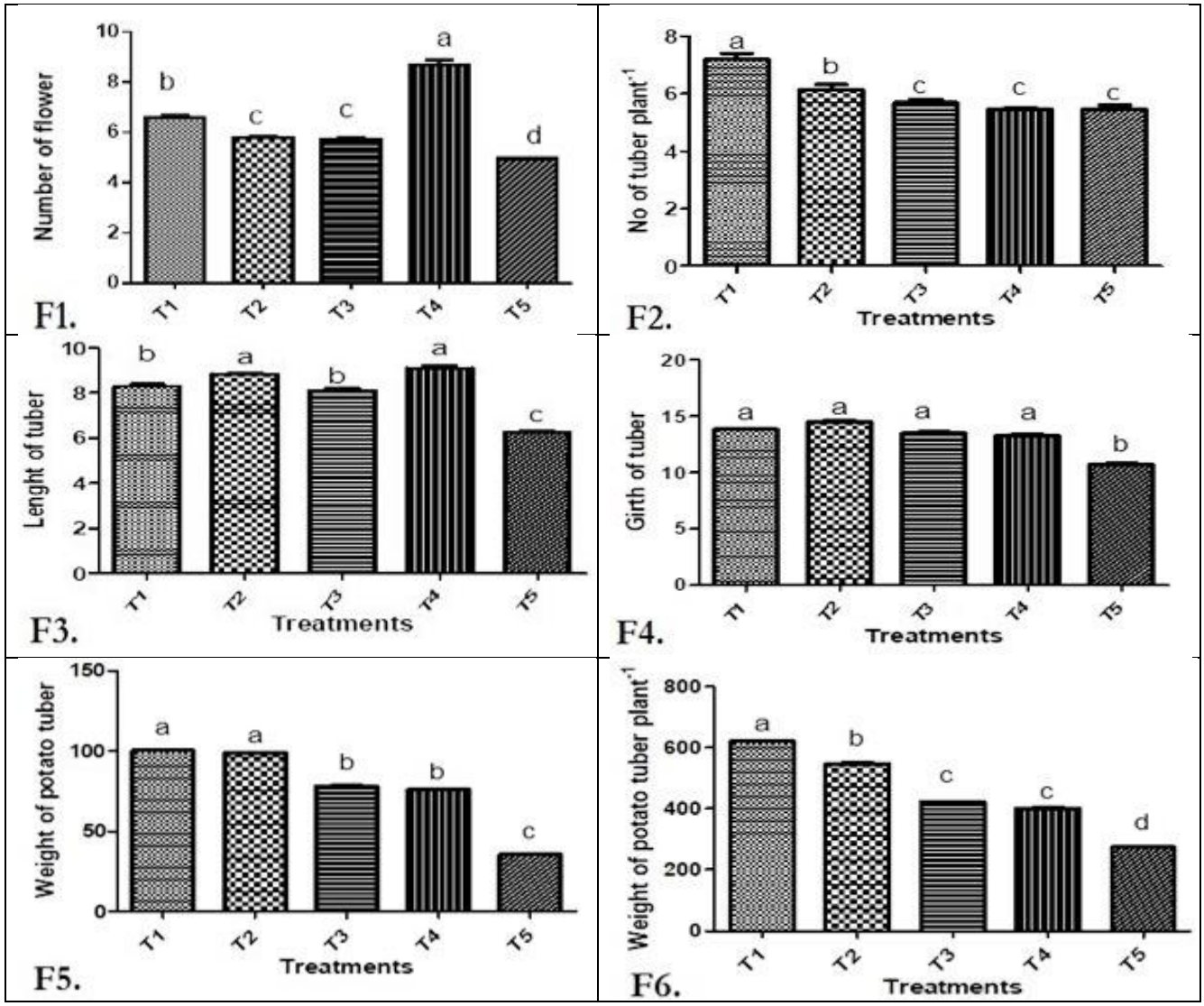
Effect of treatments on the number of leaves, flowers, Number and length of lateral stems Plant^{-1}: The present result showed that nitrogen fertilizer has a significant effect on the number of compound leaves, number of flowers, number and length of lateral stem plant $^{-1}$ (Table 1). Farmyard manure and fertilizers have a vital role in crop production. It increased chlorophyll concentration due to the increase in potash levels (Patel *et al.*, 2000; Al-Moshileh *et al.*, 2005). The highest value of compound leaves (81.00) was noted under DAP fertilizer, while the lowest numbers of compound leaves (49.0) were found in the control treatment. The highest mean average value of leaflets (10) was observed in treatment with farmyard manure while the lowest average leaflets were observed in treatment with urea. The control treatment, Nitrophos and DAP showed the same result with 7.02 leaflets. The application of nitrogen and natural fertilizer (FYM) showed a significant effect on the number and length of lateral stems. The maximum number of lateral stems (5) and lateral stem height (45.24 cm) was recorded in treatment with urea and Nitrophos fertilizer respectively while the lowest number of lateral stems (4.00) was recorded in treatment with DAP and the lowest lateral stem height (36.03 cm) was noted in the control treatment. The highest number of plant flowers (8.5) was noted under the treatment of farmyard manure, followed by treatment with Urea (6.5), Nitrophos (5.74) and DAP (5.66) respectively. The lowest number of flowers per hill (4.91) was recorded in the control treatment (Figure 1). The supply of phosphorus plays a significant role in the number of tubers produced by potato crops (Jenkins and Ali 2000). The management of fertilizers (phosphorus) is a critical component in the production of potato. (Jenkins and Ali, 2000; Rosen *et al.*, 2014). Urea is a nitrogen-based fertilizer that facilitates the availability of nitrogen in the soil. Nitrogen plays a vital role in promoting vegetative growth and overall plant development. The appropriate amount of urea helps to increase the number of leaves, lateral stems and flower production (Jenkins and Ali, 2000; Rosen *et al*., 2014). The Nitrophos have nitrogen and phosphorus and help in the development of vegetative growth like root development, flowering and improve the overall health of plants (Priyanka *et al*., 2020; Asnake *et al*., 2023). The DAP contributes to the development of roots and promotes the development of lateral stems. The phosphorus contents stimulate flower bud initiation and promote flower production. The farmyard manure improves soil fertility and nutrient uptake. The presence of beneficial microorganisms and organic matter contents in farmyard manure promotes the growth and development of the plant (Priyanka *et al*., 2020). The enhanced soil fertility can also contribute to higher flower production and potentially an increased number of leaves (Asnake *et al.*, 2023).

Effect of treatments on the number, length, girth and weight of potato tubers: The effect of different treatments (Urea, Nitrophos, DAP and Farmyard manure) on the number, length, girth and weight of potato tuber is shown in Figures 2-4. The result showed that the maximum number (7.00) of potato tubers was recorded in the T1 treatment while the minimum number (5.33) potato tubers were found in the control treatment (Figure. 2). Treatments (Urea, Nitrophos, DAP and farmyard manure) showed a significant effect on tuber length (Figure.3). The highest valves ‘was recorded by the use of farmyard manure (9.00 cm) followed by Nitrophos (8.78 cm), urea (8.21 cm) and DAP (8 cm) as compared to control (6.22 cm). The result indicates that the use of nitrogen fertilizers and farmyard manure increases the tuber girth. The highest mean average Girth of potato tuber was found by the use of Nitrophos followed by urea, DAP and farmyard manure over control (Figure. 4). The use of fertilizer promotes the growth of potato and increase the number of tubers per plant (Jenkins and Ali, 2000). The application of phosphorus increases the number of tubers per plant (Ali *et al.,* 2009). The results showed that the use of urea fertilizer increased the weight of potato tubers as compared to the control (Figures. 5-6). The highest tubers weight (100.42 g) was noted under the treatment of Urea, followed by Nitrophos (98.80 g), DAP (78.97 g) and farmyard manure (75.97g) as compared to control treatment (35.50 g). The findings are in line with earlier reports of Amara *et al*., (2013) who described the role of organic fertilizers on the growth and yield of potato. The NPK application increased the yield of potato crops (Gondwe *et al.,* 2020). The highest tuber weight (622.95 g) was noted with the use of Urea fertilizer while the lowest 273.96 mean average weights were found in the untreated control. Fertilizer showed a significant effect on tuber weight. These findings showed that highest effect of farmyard manure on tuber weight followed by Nitrophos, urea and DAP as compared to control. These results are in line with earlier reports (Zidan and Dauob 2005; Hamouz *et al.*, 2005; Al-Balikh 2008; Amara and Mourad, 2013). The N and P fertilization increases the plant height, leaf number, leaf area and tuber weight and number (Kandil *et al.,* 2011). Urea provide nitrogen to the plant which helps in promoting the vegetative growth including tuber yield and development in potatoes. The excessive use of nitrogen fertilizer may cause higher vegetative growth and smaller tubers (Hlisnikovsky *et al*., 2023). The phosphorus and potassium contents of Nitrophos improve various plant processes and helps in tuber growth and development (Gondwe *et al*., 2020). The phosphorus contents in the Nitrophos enhance tuber initiation and development and increase its length, girth and weight

Table 1: Effect of different fertilizers (Urea, Nitrophos, DAP and farmyard manure) on Plant height and Girth of Main Stem of potato plant.

Treatments	Plant Height (cm)	Girth of Main Stem	Plant compound Leaves	Leaflets/ compound leaves	Number of Lateral stems	Length of Lateral Stem (cm)
T1	76.08a	4.24a	66.00a	7.00b	5.00a	40.13a
T2	74.33a	4.66a	72.00a	7.02b	4.00ab	45.24a
T3	83.49a	4.49a	81.00a	7.02b	4.00b	45.05a
T4	79.66a	5.25a	75.00a	10.00a	5.00ab	42.77a
T5	59.33b	4.23a	49.00b	7.02b	5.00ab	36.03a
C.V%	7.97%	10.36%	9.87%	7.03%	14.12%	14.59%

Note: T1: Urea; T2: Nitrophos; T3: Di ammonium Phosphate; T4:Farmyard manure; T5: Control.



Figures : The effect of different fertilizers on different growth parameters of potato *(Solanum tuberosum* L.); F1: Effects of fertilizer on the number of flowers/plant; F2: Effects of fertilizers on the number of tuber/plant; F3: Effect of fertilizer on the length of tuber of Potato; F4: Effects of fertilizers on the Girth of Potato tuber; F5: Effects of fertilizers of the weight of tubers of potato; F6: Effects of fertilizers on the weight of potato tubers/plant; T1: Urea; T2: Nitrophos; T3: Di ammonium Phosphate; T4:Farmyard manure; T5: Control.

(Ahamad *et al*., 2014). The DAP also contains phosphorus and promote healthy roots system and support tuber development (Qadri *et al*., 2015). Farmyard manure improves soil fertility, structure, and nutrient availability. It enhances the organic matter contents in the soil and the availability of nutrients, which can support healthy root development and tuber yield (Gondwe *et al.*, 2020). The improved soil conditions provided by farmyard manure can result in larger, heavier, and more abundant potato tubers (Priyanka *et al.*, 2020).

Conclusions: The fertilizers (organic and inorganic) could significantly improve the growth, yields and morphological traits of potato crop. Application of Urea, Nitrophos, DAP and farmyard manure significantly increased potato yields. The continuous use of farmyard manure and inorganic fertilizers are important for sustainable yields. Additional field studies in Dir area are required to confirm the beneficial role of these fertilizers on the morphological growth of other varieties of potato.

Conflict of Interest: Authors have no competing interest.

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