Original Article

Response Of Radish (Raphanus Sativus L.) To Various Doses Of Phosphorous And Potassium Fertilizers

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Abstract

The research study was executed at Agricultural Research Station Swabi, during winter 2016 on "response of radish (Raphanus sativus L) to various doses of phosphorous and potassium fertilizers". This study was outlined as two factorial, split plot Randomized Complete Block design (RCBD) having three replications. The aim of this study was to observe the effect of macronutrients i.e. P and K on growth and yield of radish crop. Phosphorus at 0 kg ha^{-1}, 25 kg ha^{-1}, 50 kg ha^{-1}, 75 kg ha^{-1} and potassium at 0 kg ha^{-1}, 30 kg ha^{-1}, 60 kg ha^{-1}, 90 kg ha^{-1} were applied to radish crop. The effect of different levels on radish crop was evaluated for leaves $plant^{-1}$, leaf dry matter (%), root dry matter (%), root diameter (mm) and root length (cm). It was observed that there was a significant effect of P and K levels on growth and yield of radish. Results revealed that maximum root diameter, root dry matter, leaf dry matter was recorded in plants fertilized with 25 kg ha^{-1} phosphorous while highest leaves $plant^{-1}$ and root length was observed in control plots. Regarding potassium, highest root diameter, leaf dry matter, number of leaves $plant^{-1}$ was recorded in plots provided with 60 kg ha^{-1} potassium while maximum root dry matter and root length was observed in 30 kg ha^{-1}. Furthermore, good quality yield of radish can be achieved by providing 50 kg ha^{-1} phosphorous and 30 kg ha^{-1}.

Keywords: Radish, phosphorus, potassium, growth, yield

INTRODUCTION

Radish (Rapahnus sativus) is a root vegetable that belongs to Brassicaceae family. It can be grown both as annual and biennial crop. The edible portion is its root that develop from primary root. It is originated from central as well as western China and the Indo-Pak subcontinents (Baloch, 1994).

It is cool season crop that require mean temperature of 10-15°C for its remarkable growth and development. Being an extremely remunerative vegetable, it can be grown on wide range of soil but thrive best in sandy to sandy loam, rich and moist soil. Radishes have numerous varieties that vary in size, color and time of cultivation. There are some radishes that are grown for their seeds and oilseed radishes are grown for oil production. Radish can germinate from seed to small plant within 3 days.

Its roots can be either consumed raw or as a salad or even can be cooked as a vegetable. Its leaves can also be eaten especially when they are young and tender. It helps to prevent constipation, increase appetite and also have a cooling effect on human body. It is recommended for the patients suffering from piles, liver problem, enlarged spleen and jaundice. Radish leaves are used as leafy vegetable which are the rich source of Minerals, Vitamins A and C (Malik, 1994). It is a very excellent source of carbohydrate, Protein and Vitamin A & C (Bakhsh et al. 2006). A single cup of sliced radish roots provide twenty calories, mainly coming from carbohydrates, which make radishes a very valuable food for their caloric value. Radish contains of water, protein, carbohydrates, fiber, vitamins, fat, calcium and iron (Rice et al. 1990).

Several kinds of vegetables are grown in Pakistan. Vegetables cultivation is mostly focused in giant urban areas including Peshawar, Lahore and Karachi. Area and production of radish in Pakistan has been increased from 6454.2 to 8478.8 thousand tons from 2003 to 2012 respectively (GoP, 2012). Average annual per capita vegetable consumption was 45.6 kg in Pakistan (Agricultural Statistics of Pakistan, 2001). The major identified districts for radish production are Sheikhupura, Sahiwal, Rahim Yaar Khan, Toba Tag Singh and Okara (Chaudhary and Ahmad, 2000).

Balanced fertilizer is essential for sustainable farming in order to overcome depletion of essential nutrients. Farmers use imbalance chemical fertilizers that results in yield loss along with increase in cost of production. Furthermore it has been observed that most farmers use urea alone without addition of phosphorus and potash fertilizers. Use of balanced nutrients is extremely essential for sustainable agricultural cropping system (Mishra et al. 2014).

Phosphorus is an essential macro element necessary for growth and development of plants. Its shortage restricts growth of plants and they remain immature (Adia et al. 2013). Phosphorus is one of the essential nutrients that is required by plant body for normal growth and development. It helps the plant in metabolism of nitrogenous compounds, fats, carbohydrates along with transportation of carbohydrates (López-Arredondo et al. 2014). Due to high temperature and heavy rainfall in tropics and subtropics, phosphorus deficiency is one of the most limiting element for good crop production (López-Arredondo et al., 2014). Phosphorus is deficient in almost 30% to 40% of the world's cultivable land (Von Uexküll et al. 1995). About 80 percent of inorganic phosphorus is becoming unavailable due to the formation of complexes with oxides and hydroxides of various elements according to the nature of soil (Raghothama, 1999). Such condition is caused by inadequate use of fertilizers that leads to reduction in availability of nutrients for crop growth. Phosphorous is often deficient because major part of it in the soil is unavailable for the plants. Due this, P fertilizer is applied in heavy doses in agriculture that causes various problems i.e. increased cost of production, depletion of P resources and eutrophication.

Potassium is one of the essential macronutrients responsible for plant growth. It is required in large amount by the plant for its life cycle (White and Karley, 2010), that's why it comes in macronutrients category. Potassium is responsible for cell extension, synthesis of protein, sugar transportation, nitrogen & carbon metabolism and photosynthesis (Inam et al. 2011). Furthermore it is responsible to improve qualitative and quantitative parameters of a crop (Marschner, 2011; Oosterhuis et al. 2014). The mobile nature of potassium in plants helps to regulate osmotic pressure of the cell and it is responsible for balancing cations and anions of the cytoplasm (Hu et al. 2016). Potassium is also involved in opening and closing of stomata and many more important physiological processes of the plant. Higher amounts of potassium is required by radish crop to obtain a quality yield (Brinth and Seran, 2009).

Keep in view the importance of phosphorus and potassium, the present research was initiated to evaluate the performance of radish through the provision of different doses of P and K at agro-climatic condition of Swabi, Khyber Pakhtunkhwa, Pakistan. Furthermore, to optimize the productive level of phosphorous and potassium regarding growth and yield of radish.

MATERIALS AND METHODS

The experiment on 'response of radish (Raphanus sativus L) to various doses of phosphorous and potassium fertilizers' was carried out at Agriculture Research Station Swabi during 2016. The experiment was laid out in

Randomized Complete Block Design (RCBD) with split plot arrangement. Four levels of phosphorus at the rate 0, 25, 50 and 75 kg ha^{-1} were applied to main plots, while four dozes of potassium at the rate 0, 30, 60 and 90 kg ha^{-1} were assigned to subplots. There were a total of 16 treatment combinations and experiment were replicated three times.

Field was prepared well i.e. ploughed and levelled before seeds sowing for efficient distribution of irrigation water. "White globe" cultivar of radish was sown by maintaining plant to plant and row to row distances of 1 and 2 ft. respectively. All other cultural practices i.e. weeding, hoeing etc. were done when required for good growth and hygiene

Data were recorded on the following parameters.

Number of leaves:

Number of leaves were counted from five randomly selected plants in each plot of a replication at the end of the season and then mean values were calculated.

Leaf length:

Leaf length was measured via measuring tape from each replication by randomly selected five plants per plot at crop maturity and them average was calculated.

Leaf width:

Leaf width was measured with the help of measuring tape by randomly selected plants in each treatment and then mean was computed.

Root dry matter:

Roots of five plants were randomly selected from each treatment, first their fresh weight was taken and after that individual roots were tagged. Tagged roots were dried in an oven for 48 hours at 70 C° and then dry matter was calculated by using the following formula:

$$\text{Dry Matter (\%)} = \frac{\text{Fresh weight} - \text{Dry weight}}{\text{Fresh weight}} \times 100$$

Leaf dry matter:

Leaves of five plants were randomly selected from each treatment, first their fresh weight was taken and after that individual leaves were tagged. Tagged leaves were dried in an oven for 48 hours at 70 C° and then dry matter was calculated by using the following formula:

$$\text{Dry Matter (\%)} = \frac{\text{Fresh weight} - \text{Dry weight}}{\text{Fresh weight}} \times 100$$

RESULTS AND DISCUSSIONS

1 Root diameter:

The means data pertaining to root diameter is given in Table 1 that shows that there was a significant effect of potassium and phosphorus on root diameter of radish crop. The interactive effect of both phosphorus and potassium on root diameter of radish was also found significant. It is clear from the mean data that the highest root diameter (3.68 inch) was recorded in radish plants fertilized with 60 $kgha^{-1}$ of potassium while minimum root diameter (3.56 inch) observed in crop fertilized with 90 kg ha^{-1} of potassium. In regards to phosphorus, the highest root diameter (3.95 inch) was observed in plants supplied with 25kg ha^{-1}phosphorus; however the least diameter (3.37 inch) recorded with 75 kg ha^{-1} phosphorus. The interactive effect of potassium and phosphorus leads to variation in root thickness of radish crop. The highest root diameter (4.69 inch) was achieved in plants fertilized with 30 and 50 $kgha^{-1}$of phosphorus and potassium respectively, however, the minimum root diameter (2.84 inch) was recorded in plants that were grown in plots fertilized with 90 and 75 kg ha^{-1} phosphorus and potassium respectively. Our results revealed that adequate application of potassium increases root diameter in radish crop but high doses recorded worst resutls. Our findings are similar with the results of Chhetri et al. 2019, who observed that application of potassium at the rate of 50 kg ha^{-1} increases root girth in radishes. Furthermore, low dose of phosphorus produces thick radishes while increase in dose reduces the thickness of radish roots. Zeb et al. 2021 also recorded that application of phosphorus leads to increase in root girth of radish plant. Our result was superior regarding root diameter of radish when supplied with 25 kg ha^{-1} while Zeb et al. 2021 thickest root in 60 kg ha^{-1} phosphorous treated plots. This might me due to difference in the presence of soil phosphorous.

2 Root dry matter (%):

The mean values given in table 2 indicates the significant variation in root dry matter when radish crop was fertilized with different levels of phosphorus and potassium. The interactive effect of both the nutrients was also found significant. The highest root percent dry matter (93.93 %) was recorded in radish crop broadcasted with 25 kg ha^{-1} of phosphorus, however minimum root percent dry matter (92.36 %) recorded in plants that were fertilized with 50 kg ha^{-1} of phosphorus. In regards to potassium, the highest root percent dry matter (93.94 %) was recorded in radish plants supplied with 30 kg ha^{-1} of potassium however lowest root percent dry matter (92.19%) was observed in control plots. The interactive effect of potassium and phosphorus on root percent dry matter of radish was also significant. The highest root percent dry matter (94.99%) was recorded in plants fertilized with 25 and 0 kg ha^{-1} of phosphorus and potash respectively, however, the minimum root percent dry matter (90.98 %) recorded in plants, received 75 and 60kg ha^{-1} phosphorus and potash respectively. Our results indicates that adequate application of phosphorous enhances root dry matter in radish crop. Zeb et al. 2019 result was contrary to our, who reported that root dry matter was not affected with application of phosphorous. . This might be due to the difference in soil phosprous, as Zeb et al. radish crop was grown in latosols. Phosphorous application positively affect the crop when the soil is deficient of phosphorous but the crop does not respond when phosphorus presence in the soil is high. Furthermore, potassium application in low dose increases root dry matter. Result of de Sousa Gouveia et al, 2018 is contrary with our, who recorded that potassium had no effect of root dry matter. This might be due to the difference in soil potassium of Pakistan and Brasil.

Table 1. Effect of phosphorus and potassium on root diameter (inch) of radish

Phosphorus	Potassium				Means
	0	30	60	90	
0	3.66 bcde	4.04 b	3.42 def	3.44 def	3.45 bc
25	3.67 bcde	3.82 bcd	3.59 cde	3.36 efg	3.95 a
50	2.98 gh	4.69 a	3.47 cdef	3.59 cde	3.59 b
75	3.51 cdef	3.14 fgh	3.88bc	2.84 h	3.37 c
Means	3.64 a	3.62 a	3.68 a	3.56 b	

LSD value at 5% for phosphorus (P) = 0.2697
LSD value at 5% for potassium (K) = 0.3115
LSD value at 5% for P × K =0.6229

Table 2. Effect of phosphorus and potassium on (%) root dry matter of radish

Phosphorus	Potassium				Means
	0	30	60	90	
0	91.11 f	93.55 cd	91.90 e	92.19 e	92.97 b
25	94.99 a	93.64 cd	93.25 d	93.87 bcd	93.93 a
50	92.07 e	94.12 bc	93.32 d	92.32 e	92.36 c
75	93.71 cd	94.40 ab	90.98 f	93.77 cd	93.04 b
Means	92.19 c	93.94 a	92.96 b	93.22 b	

LSD value at 5% for phosphorus (P) = 0.3115
LSD value at 5% for potassium (K) = 0.3115
LSD value at 5% for P × K = 0.6229

3. Leaves Dry Matter (%):

Data regarding leaves dry matter given in Table 3 reveals that there was a significant effect of potassium and phosphorus on leaves dry matter percent in radish crop. As it is clear from the table that the maximum leaves percent dry matter (91.14%) was recorded in radish plants fertilized with 60 kg ha^{-1} of potassium however minimum root percent dry matter (89.65%) observed in plants, fertilized with 0 kg ha^{-1} of potash. Regarding phosphorous, the highest leaves dry matter (90.98%) was observed in plants provided with 25kg ha^{-1} phosphorus; however the least leaves dry matter (89.95%) was recorded with 75 kg ha^{-1} phosphorus. The interactive effect of potassium and phosphorus on leaves percent dry matter of radish was also significant. The highest leaves percent dry matter (92.61%) was observed in plants, fertilized with 50 and 30 kg ha^{-1} of phosphorus and potassium respectively, however, the minimum leaves percent dry matter (87.68%) recorded in plants, received 75 and 90kg ha^{-1} phosphorus and potassium respectively. Our finding revealed that dry matter of leaves increases with the application of potassium. Similar result was recorded by Islam et al. 2004, who observed that application of high dose of potassium in adequate moisture reported maximum dry matter of leaves in bushbean. Similar results about potassium responsible to increase to dry matter of leaves in carrot crop was recorded by Subba et al 2017. Regarding phosphorous, maximum dry matter of leaves was recorded in radish when provided adequate amount of phosphorus. Similar result was obtained by Rodriguez and Goudriaan (1995), who observed that application of low dose of phosphorous to wheat was at par with the high doses and lowest in control. Ayub et al. (2002) also recorded significant variation regarding plant dry matter in maize crop when phosphorous was provided in different doses.

4. Number of Leaves:

Values given in Table 4 reveals that there was a significant effect of potassium and phosphorus and the interaction of both on number of leaves of radish crop. Highest number of leaves (21.66) was recorded in radish plants grown in control plots however minimum number of leaves (20.16) were observed in plants broadcasted with fertilizer having 60 kg ha^{-1} of potassium. In regards to phosphorus, the highest number of leaves (23.33) was observed in plants treated with 0 kg ha^{-1} phosphorus while the least number of leaves (18.69) were recorded with 75 kg ha^{-1} phosphorus. The highest number of leaves (24.33) were observed in plants fertilized with combination of 75 kg ha^{-1} phosphorous and 0 kg ha^{-1} of phosphorus and potassium respectively while the minimum number of leaves (17.66) were recorded crop supplied with 25 and 90 kg ha^{-1} phosphorus and potassium respectively. Our findings indicates that provision of 60 kg ha^{-1} to the radish field resulted in maximum number of leaves per plant. Similar result was obtained by Subba et al 2017, who reported that high dose of potassium increased number of leaves in carrot crop when nitrogen was kept constant for all the treatments. In regards to phosphorous, number of leaves in radish crop was higher in control plots. Study of Kim and Li (2016) also revealed that phosphorous has a significant impact on number of leaves in Lantana.

Table 3. Effect of phosphorus and potassium on Leaves Dry Matter (%) of radish

	Potassium				
Phosphorus	0	30	60	90	Means
0	87.88 e	89.93 cd	90.32 c	90.47 bc	90.06 b
25	91.48 abc	91.48 abc	88.54 de	90.57 bc	90.98 a
50	90.31 c	92.61 a	90.59 bc	91.073 abc	90.37 ab
75	90.60 bc	89.88 cd	92.05 ab	87.68 e	89.95 b

Means	89.65 c	90.523 ab	91.14 a	90.05 bc	

LSD value at 5% for phosphorus (P) = 0.8284
LSD value at 5% for potassium (K) = 0.8284
LSD value at 5% for P × K = 1.6567

Table 4. Effect of phosphorus and potash on number of leaves

Phosphorus	Potassium				Means
	0	30	60	90	
0	24.11 a	23.66 ab	18.99 ef	19.88 de	23.33 a
25	22.99 abc	22.88 abc	19.22 ef	17.66 f	21.13 b
50	21.88 bcd	18.77 ef	21.55 bcd	18.44 ef	20.30 b
75	24.33 a	19.22 ef	21.44 cd	18.77 ef	18.69 c
Means	21.66 a	20.69 ab	20.16 b	20.94 ab	

LSD value at 5% for phosphorus (P) = 1.0687
LSD value at 5% for potassium (K) = 1.0687
LSD value at 5% for P × K = 2.1374

5. Root Length:
The means data concerning root length given in Table 5 reveals that there was a significant effect of potassium, phosphorus and interaction of both on root length of radish crop. Longest roots (26.31cm) were produced by radish plants when fertilized with 30 kg ha^{-1} potassium while shortest roots (24.26 cm) were produced by the crop that 90 kg ha^{-1} of potassium. Regarding phosphorus, highest root length (27.93 cm) was observed in plants in control plots while least length (23.25cm) was recorded with 75 kg ha^{-1} phosphorus. In regards to interactive effect of potash and phosphorus, highest root length (29.85 cm) was observed in plants fertilized with 0 and 30 kg ha^{-1} of phosphorus and potassium respectively, however, the minimum root length (20.84 cm) was recorded in plants that received 75 and 30 kg ha^{-1} phosphorus and potassium respectively. It is clear form our results that adequate dose of potassium increases root length in radish. Similar finding was obtained by Subba et al 2017, who observed that application of potassium to carrot field resulted in long roots. A significant effect of phosphorous was observed in root length of radish crop. Satari et al. 2020 also observed significant variation when phosphorus along with other nutrients were provided in different concentrations.

Table 5. Effect of phosphorus and potash on root length (cm)

Phosphorus	Potassium				Means
	0	30	60	90	
0	27.07 cd	29.85 a	24.17 ef	23.15 f	27.93 a
25	27.67 c	26.33 d	27.10 cd	24.16 ef	25.34 c
50	28.91 ab	24.35 e	26.90 cd	23.98 ef	26.15 b
75	28.07 bc	20.84 g	26.43 d	21.72 g	23.25 d
Means	26.04 a	26.31 a	26.05 a	24.26 b	

LSD value at 5% for phosphorus (P) = 5.8579

LSD value at 5% for potassium (K) = 5.8579

LSD value at 5% for P × K =11.716

CONCLUSION AND RECOMMENDATION

Based on results of the present experiment, the following conclusions and recommendations were drawn:
Above results revealed that potassium and phosphorus plays a vital role in growth and yield of radish plant. It can be concluded that there is a significant impact of phosphorus and potassium levels on all the observed growth and

yield related parameter in radish crop. Results indicates that maximum root diameter, root dry matter, leaf dry matter was produced by the plants fertilized with 25 kg ha^{-1} phosphorous while maximum leaves $plant^{-1}$ and root length was observed in untreated plants. About potassium, highest root diameter, leaf dry matter, number of leaves $plant^{-1}$ was reported in plots supplied with 60 kg ha^{-1} potassium while maximum root dry matter and root length was observed in 30 kg ha^{-1}. Furthermore, good quality yield of radish can be achieved by providing 50 kg ha^{-1} phosphorous and 30 kg ha^{-1}. It can recommended that fertilize your radish with 25 kg ha^{-1} phosphorous and 60 kg ha^{-1} when provided separately. The combination of 50 kg phosphorous and 30 kg potassium is recommended for one hectare radish field.

Declaration

Data availability

All data and materials are available from the corresponding author. Therefore, at a reasonable request, the corresponding author shared it via email.

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