GROWTH AND SEED PRODUCTIVITY OF D*AUCUS CARROTA* ENHANCED WITH ROOTS DIMENSIONS AND RHIZOSPHERIC PHOSPHOROUS FERTILIZATION

Mohammad Ilyas[1], Shah Zaib[2], Muhammad Ismail[3], Qazi ShoaibAli[4], Solevo Martin[4], Muhammad Amir[4], Noor ul wahab[3], Jan Nisar[3], Sajid Ali[5], Naveed Ul Haq[6], Imran Qazi[4], Imran[5]

1. Department of Agriculture Hazara University, Manshera Pakistan
2. Directorate of Agriculture Research, Loralai-Balochistan
3. Department of Horticulture Abdul Wali Khan University Mardan, Pakistan
4. Department of Horticulture, The University of Agriculture, Peshawar Pakistan.
5. Department of Agronomy, The University of Agriculture Peshawar
6. Department of Food Science, The University of Guelph, Canada.

ABSTRACT

Field experiments were conducted with four different dimensions of carrot roots (5, 10, 15 & 20) and four different P levels (0, 50, 75 and100 kg ha^{-1}) to evaluate the response of carrot growth, development, seed yield umble^{-1} under the semi-arid climatic condition. Total 16 treatments in various combinations were used in four replications.Results showed that large and thick root dimension of 20 cm effected days to flowering and produced early flowering as compared to other treatments. P fertilization also influenced carrot phenology and noted that early flowering produced by carrots with P fertilization up to 100 kgha^{-1}. Taller plantswere produced by 10 cm root size, which was statistically similar to 15 cm root dimension while dwarf seedling were recorded in 5 cm root dimension. Increasing phosphorous level showed ameliorating effect towards carrot growth and shoot improvement and noted highest carrot shoot with 100 kg P ha^{-1}.It was worthy noted that P fertilization was promising for improvement in umbel plant^{-1}and we observed with P application of 100 kg ha^{-1}. Similarly optimum root dimension of about 15 cm resulted in more number of umbel plant^{-1} that was decreased with small size of root thickness. Highest seed yield umbel^{-1} was recorded in plants treated with 100 kg P ha$^{-1.}$ Similarly root dimension of 20 cm produced more seed yield umbel^{-1}, whereas least seed yield umbel^{-1} was recorded in roots of stickling size of 5 cm.

Key words*: Carrot, (Daucuscarrota*), *phosphorous, seed production, roots dimension*

Introduction

Carrot (*Daucuscarota*) belongs to family *Umbelliferae* grown in winter season in Pakistan. Carrot is grown around the world as an important vegetable crop as human food supplement and high yielding capacity per unit area. Asia is the native land of carrot cultivation and Pakistan agrometeorological conditions are considered an ideal for carrot and seed production. Carrot is rich source of mineral and nutrients essential for human body and known as poor man apple (Baloch, 1994). Carrot could be grown on high elevation with optimum temperature but it can also be raised in the tropics. Carrot is known rich source of carotene which contain a good amount of thiamine and riboflavin with sufficient sugar concentration. Carrot is mostly used as a raw food but it can also be cooked in curries and also be used as a component for pickles and sweet meats. The taproot is the most widely consumed portion of the plant although the stems and leaves are also consumed. There is strong evidence that carrot stem consist on special carotene, known as alpha and beta carotene which improve vision and make the eyes clear, soft and effective sighted. It also contains vitamin K and B6 which is important for human health and eye sightness. Many studies reported that for the manufacturing of AMP, ADP and ATP which are the energy rich compound, P availability is necessary for its preparation inside the plant body (Imran et al., 2020a; Karim and Imran. 2019; Imran et al., 2018; Imran 2018a). It has been also reported that these energy rich compounds are the important components for photosynthesis and respiration (Imran et al., 2020a; Imran et al., 2020b; Imran et al., 2019a; Ali et al., 2019).With limited or no phosphorus, formation of meristem tissue; root growth, flowering and development of seed and fruits are drastically decreased (Imran 2018b; Imran. 2018c; Imran 2018d). it also cause stunted growth of the plant, purple or reddish leaves, stems and branches, less yield and low quality of crops (wood *et al.,* 1994). It has been noted that phosphorus application enhance carrot growth and development and play promising role in seed development and production under temperate environment. The farming community of Pakistan, mostly producing carrot seed from roots to seed method which is the most popular and promising method for obtaining good quality and healthy seeds, for obtaining disease free and viable seeds, this method is considered an ideal method to obtain in which good color of stickling are select for replantation which result in true to type and good quality of seed. The basic problem for carrot production is the unavailability of high quality seed (Imran and Amanullah. 2018; Imran. 2018e; Imran and Khan 2017). Much work has been carried out on production side, while no attention has been given on seed production in carrot. Carrot roots (the part of the plant we eat) can rise in length from 2 to 12 inches (5 to 30 centimeters). Many carrot roots can grow up to 12 inches long (not counting the greens that grow above ground) because a carrot's entire root grows underground.There is lack of research studies regarding roots dimension and various carrot stem size with context to P fertilization for attaining seed yield. Currently no study has been documented in this context having assessment of P fertilization and roots size for seed production of roots to seed method. Therefore this study was designed to know the response of carrot growth and seed production towards roots dimension and P fertilization.

MATERIALS AND METHODS

Experimental site

Field experiment was carried out at Agriculture research farm Hazara University Mansehra during winter 2019-20 to find out the best root size and phosphorus level for optimum growth and seed production of carrot. The soil of the experiment was deficient in soil phosphorus and organic matter. The soil was analyzed before sowing to determine soil texture, class, available P, K, N and organic matter. Lim contents were also determined to know the soil either acidic or calcareous. Field trial were conducted with randomized complete block design with three replication. The seed of carrot were sown in the last week of October 2019 using a cultivar "Shan" according to the agro climatic condition of Mansehra. After emergence and roots establishment, Roots were transplanted immediately for seed production purposes. Uniform size, true to type roots for each treatment were selected based upon color and its dimension and transplanted to obtain good quality seed. The roots dimension were maintained to various treatments according to experiment(5 cm, 10 cm, 15 cm, and 20 cm) from the root tip and got stickling of 5 cm, 10 cm, 15 cm and 20 cm respectively. A total of forty eight sub plots were grown. The plot size was kept 2×2(4m^2), with 45 cm plant to plant distance and 75 cm row to row distance were maintained. Raised beds of about 30 cm high were used for planting the roots. Four levels of phosphorus were used (0, 50, 75 and 100 kg ha^{-1}) in the form of single super phosphate during the experiment. Phosphorus levelswere treated assigned tomain plot, whilevarious rootdimension were assigned to sub plot. Basal done of N in the form of urea was applied in two splits at the rate of 100 kg ha^{-1} whereas K was treated at the rate of 125 kg ha-125 kg ha^{-1}. Half dose of nitrogen (50 kg ha^{-1}) was applied at the time of transplanting while the remaining half was treated before the flowering. The organic manures in the form of FYM were also treated to improve physico-chemical properties of the soil. All other cultural practices were remained the same in all experimental units.

RESULTS AND DISCUSSION

Growth parameters:

Days to flowering

Carrot rootsdimension and phosphorous fertilization significantly affected days to flowering. Large root size of 20 cm showed significant decrease in days to flowering as compared to other treatments (Fig. 1). Similarly increased in phosphorous fertilizer resulted early flowering than control. Early flowering was recorded in plants fertilized with 100 kg ha^{-1} (Table-1). The findings are closely related to that of Sharma (2000) who reported that maximum phosphorous levels caused early flowering in raddish. These results are strongly correlated with those of Arya and Saini, (1977) andBujdosa and Hrsako, (1983) who reported that days to flowering were affected by root size and early flowering was noted with maximum roots dimension transplanted carrots. The possible reason could be that large size roots are rich in carotenoids, anthocyanins, dietary fiber, vitamins and other nutrients and can play their role in plant growth and development and may have enhanced early flowering as compared to the other roots dimension planted carrots. Another possible reason could be that carrot serve as sources of antioxidants, which have important functions for the prevention of many diseases and thus leading the plant to healthy growth and production. Phosphorus application can regulate hormonal functions in carrot which initiate early or delayed flowering during vegetative life period. These results were supported by Baloch (1994) who determined that optimum growth and development in carrots could be observed with phosphorus fertilization and large roots dimension under high elevation. Many researchers reported that with no P fertilization, plant growth and development significantly reduced and effect the plant dry biomass and productivity which ultimately leading to food insurgency (Imran et al., 2020a; Imran et al., .2020b; Imran et al., 2019a; Ali et al., 2019). In limited P application or no P fertilization, plants cannot grow as it is a key component of nucleic acids, phospholipids and ATP and without these components plant cannot survive (Imran 2018b; Imran. 2018c; Imran 2018d).

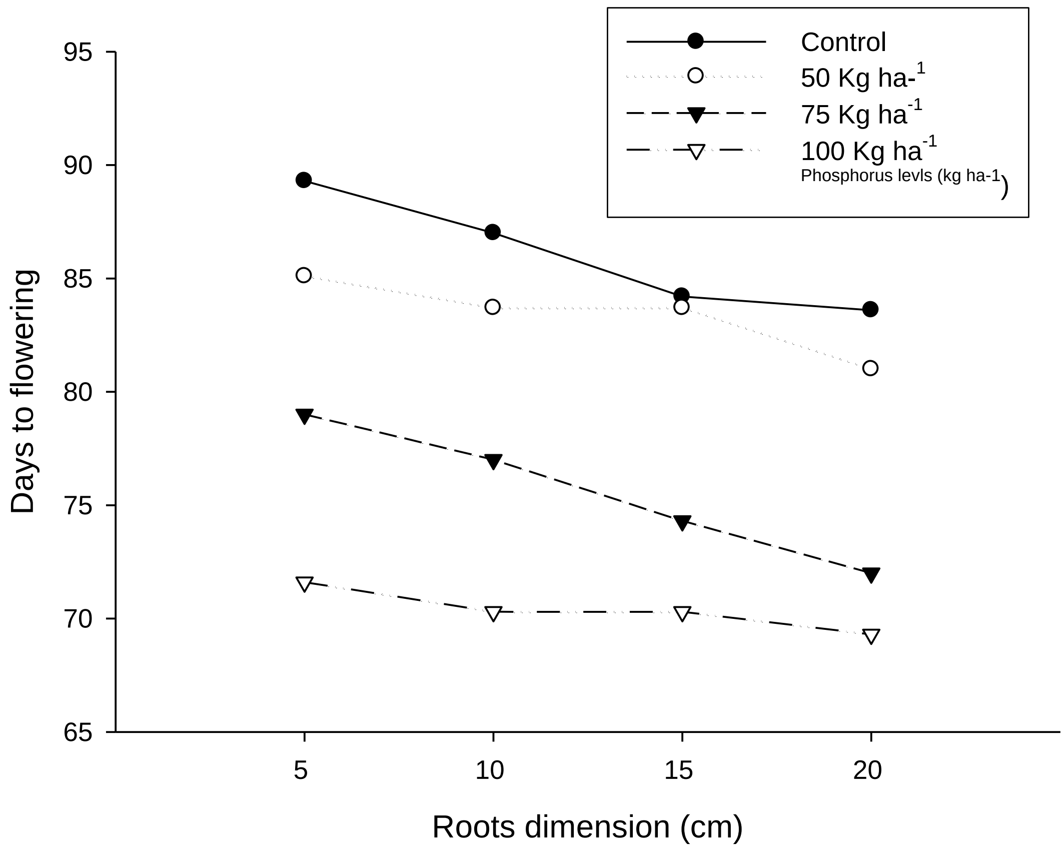

Fig. 1 Days to flowering of carrot as influenced by various roots dimension and phosphorus levels

Table 1. Root size and phosphorous effect on Days to flowering of carrot.

Phosphorous levels					
Root size	**Control**	**50 Kg ha^{-1}**	**75 Kg ha^{-1}**	**100 Kg ha^{-1}**	**Means**
5 cm	89.3	85.1	79.0	71.6	81.3 a
10 cm	87.0	83.7	77.0	70.3	79.5 b
15 cm	84.2	83.7	74.3	70.3	78.1 c
20 cm	83.6	81.0	72.0	69.3	76.5 d
Means	86.0 a	83.4 b	75.6 c	70.4 d	

Plant Height (cm)

Among the different root size, maximum plant height was recorded in seedling from 10 cm root, which was statistically similarto 15 cm root while smallest plants were recorded in seedling of small root size (Fig. 2). Increasing phosphorous level resulted in tallest plants. Maximum plant height was recorded in plants supplied with phosphorous @ 100 kg ha^{-1} as compared to control (Table 2). Wood*et al*. (1994) reported that the phosphorous is essential for cell division and promote stalk strength and growth which in turn increase plant height. These results were supported by Mishra (1987) who obtained more plant height (170.0 cm) by phosphorus fertilization with highest level as compared with low level of P in radish. These findings are in connection with those of Akbar and Amjad (2002) who reported that large size root and wider space resulted in maximum plant height in carrot as compared to small size roots and small space. The possible reason could be that phytohormones regulation take place with optimum fertilization which play an important role in controlling plant root growth and development. It was concluded that fluctuation in plant height might be due to the activation and regulation of phytohormones with rhizospheric P fertilization and roots dimension (Fig. 5). Another possible reason could be that hormones activate molecular mechanisms of carrot which promote plant growth and development.Our findings are closely related to those of Arya and Saini (1977) and Paradisi and Montanari (1985) who observed an increase in the seed yield of kg ha^{-1} by planting a large root in carrots. Root size and P effect on carrot seed yield (t ha^{-1}). Large root contains more staple food which could be used for the production of vigorous plant body with a maximum number of umbels, umbellate and number of seeds. These parameters will be maximum with more food stored (Hamid et al., 2002). The increase in carrot yield with phosphorous application might be due to the role of phosphorous in improving soil fertility and increasing availability of nutrients.Limited P supply in bulk soil effect P uptake by plants as it is only move by the process of diffusion and do not uptake or very low amount is uptake by the crop plants which is an alarming threat for low productivity (Imran, et al., 2015b; Imran et al., 2019b). Other researcher reported that P is very rarely available in soil or only available in soil out of the rhizosphere which cannot support the plant for high growth rate and development (Amanullah et al., 2020; Imran et al., 2020c; Imran et al., 2017a). Phosphorus application is necessary in agriculture system to ensure crop productivity and food security (Imran et al., 2017b; Imran 2017; Imran et al., 2015a).

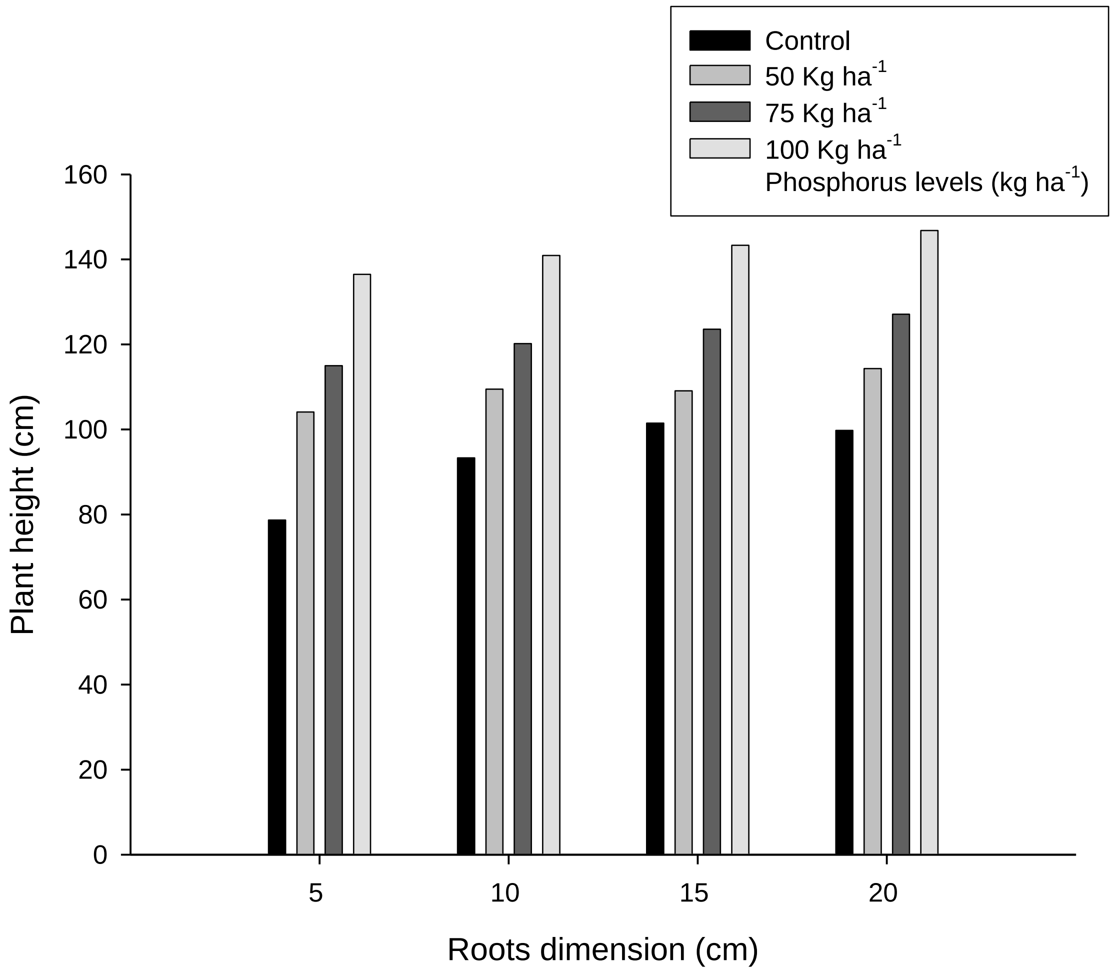

Fig. 2 Carrot plant height influenced by various roots dimension and phosphorus levels

Table 2. Root size and phosphorous effect on carrot plant height (cm).

Phosphorous levels					
Root size	**Control**	**50 Kg ha^{-1}**	**75 Kg ha^{-1}**	**100 Kg ha^{-1}**	**Means**
5 cm	78.7	104.1	115.0	136.5	108.6 c
10 cm	93.3	109.5	120.2	140.9	116.0 b
15 cm	101.5	109.1	123.6	143.3	119.4 a
20 cm	99.8	114.3	127.1	146.8	123.1 a
Means	99.8 d	109.3 c	121.5 b	141.9 a	

Yield and yield components

Number of Productive stems plant^{-1}

Phosphorous(P) application enhanced number of productive stems plant^{-1}(NPSP) while decrease was noted as the phosphorous level was gradually decreased. It was noted that NPSP was correlated with the P fertilization. As the P level increased from the lowest to the highest level, NPSP was gradually increased. Among different root size more plants with root size of 15 cm resulted in more NPSP that were significantly different from other treatments. This increase in NPSP with high phosphorous might be due to increased root growth, which in turn increase area for nutrients and water absorption promote vigorous plant growth. The results are supported by that of Gill *et al*., 1995 who reported increase in NPSP of radish with increasing the application of phosphorus than control (no P). Increase in number of flowering stalk in radish cultivar 'Mino White' was recorded by in plants with big root size as compared to small root. our findings are closely related to those of Arya and Saini (1977) and Paradisi and Montanari (1985) who reported that NPSP could be improved with optimum time of transplanting and P fertilization. Hamid et al, (2002) reported that growth and yield contributing parameters increases with roots size and more food storage in the roots. The increase in carrot yield by phosphorous application may be due to the role of phosphorous in improving soil fertility and increasing availability of nutrients. They observed an increase in the seed yield of kg ha-1 by planting a large root in carrots. Large root contains more staple food which could be used for the production of vigorous plant body with a maximum number of umbels, umbellate and number of seeds. It has been reported that P is an important plant metabolism component and making 0.2% of the plant dry weight (Karim and Imran. 2019; Imran et al., 2018; Imran 2018a). Therefore P fertilization is needed as it is an important major plant nutrients after N. In limited P application or no P fertilization, plants cannot grow as it is a key component of nucleic acids, phospholipids and ATP and without these components plant cannot survive (Imran 2018b; Imran. 2018c; Imran 2018d). Many researchers reported that with no P fertilization, plant growth and development significantly reduced and effect the plant dry biomass and productivity which ultimately leading to food insurgency (Imran et al., 2020a; Imran et al., .2020b; Imran et al., 2019a; Ali et al., 2019).

Table 3. Root size and phosphorous effect on number of productive stems plant^{-1} of carrot.

	Phosphorous levels				
Root size	**Control**	**50 Kg ha^{-1}**	**75 Kg ha^{-1}**	**100 Kg ha^{-1}**	**Means**
5 cm	7.1	9.2	9.9	11.3	9.4 c
10 cm	11.7	12.1	14.7	13.7	13.0 bc
15 cm	12.9	12.6	14.3	14.0	13.4 b
20 cm	15.4	16.0	13.0	16.6	15.0 a
Means	11.8 c	12.5 bc	12.9 b	13.9 a	

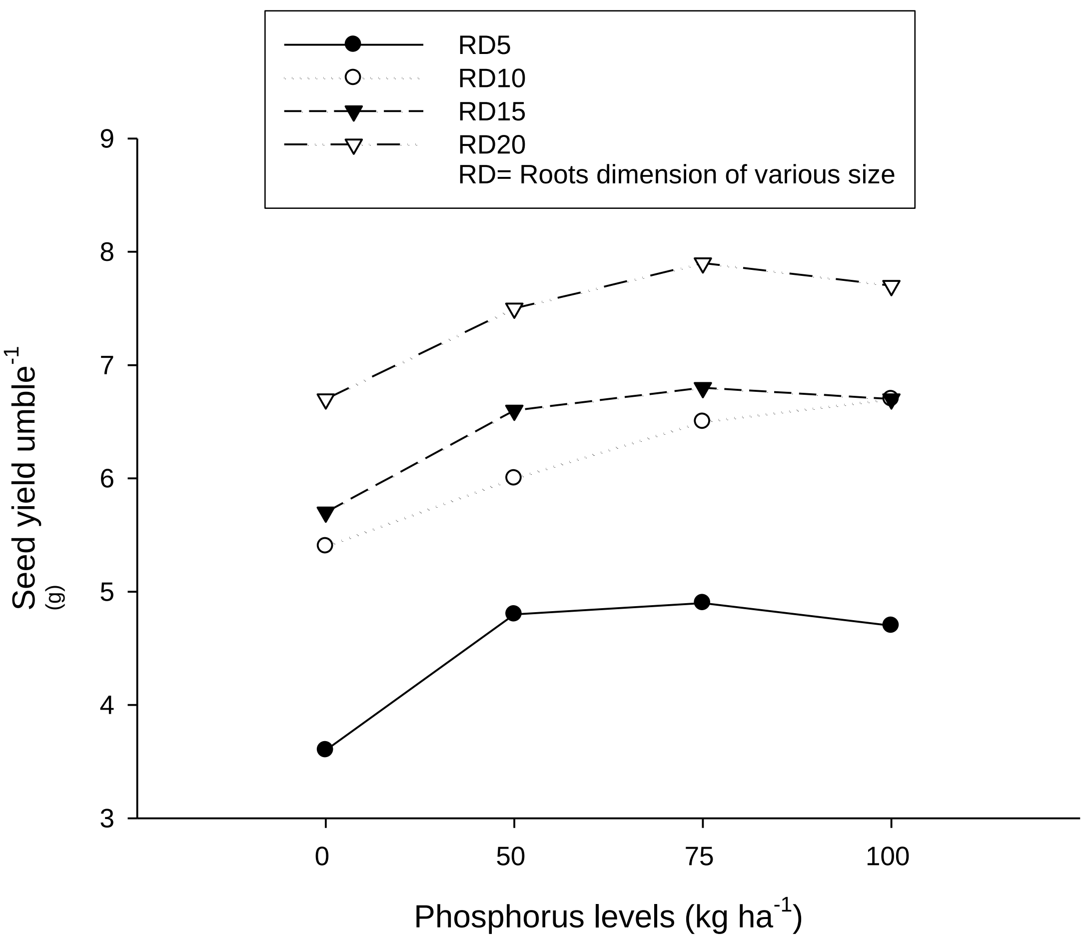

Fig. 3 Carrot seed yield umble^{-1} as influenced by various roots dimension and phosphorus levels

Number of umbel plant^{-1}

Number of umbel plant^{-1} (NUP) responded positively to P fertilization and roots dimension. P level up to 100 kg ha^{-1} produced more NUP as compared to other treatments. Similarly optimum root size of about 15 cm resulted in maximum NUP that was decreased with small size of root. Regarding the interactionsusing a rot size of about 15 cm with the application of phosphorous @ 100 kg ha^{-1} showed increase in NUP. Our Results are in harmony with that of Singh *et al*. (1991), who reported that basal doze of nitrogen with maximum doze of phosphorous resulted in increased NUP in carrot. Our findings are closely related to those of Arya and Saini (1977) and Paradisi and Montanari (1985). They observed an increase in the seed yield of kg ha-1 by planting a large root in carrots. Root size and P effect on carrot seed yield (t ha-1). Large root contains more staple food which could be used for the production of vigorous plant body with a maximum NUP, umbellate and number of seeds. The increase in NUPas a result of increase in root size may be due the fact, that large root containsmore store food which might be used as a source for vigor plant growth. Eid and Sedra (1992) also reported the same results that large size roots produce maximum NUP. Many researchers reported that with no P fertilization, plant growth and development significantly reduced and effect the plant dry biomass and productivity which ultimately leading to food insurgency (Imran et al., 2020a; Imran et al., .2020b; Imran et al., 2019a; Ali et al., 2019). It has been reported that P is an important plant metabolism component and making 0.2% of the plant dry weight (Karim and Imran. 2019; Imran et al., 2018; Imran 2018a). Therefore P fertilization is needed as it is an important major plant nutrients after N. In limited P application or no P fertilization, plants cannot grow as it is a key component of nucleic acids, phospholipids and ATP and without these components plant cannot survive (Imran 2018b; Imran. 2018c; Imran 2018d). Phosphorus is involved in controlling and regulating several enzymatic function and reaction in metabolic pathway and thus regulating plant growth and development and ultimately plant productivity and yield (Imran and Amanullah. 2018; Imran. 2018e; Imran and Khan 2017). Other researcher reported that P is very rarely available in soil or only available in soil out of the rhizosphere which cannot support the plant for high growth rate and development (Amanullah et al., 2020; Imran et al., 2020c; Imran et al., 2017a).Phosphorus application is necessary in agriculture system to ensure crop productivity and food security (Imran et al., 2017b; Imran 2017; Imran et al., 2015a). Limited P supply in bulk soil effect P uptake by plants as it is only move by the process of diffusion and do not uptake or very low amount is uptake by the crop plants which is an alarming threat for low productivity (Imran, et al., 2015b; Imran,et al., 2019b)

Table 4. Root size and phosphorous effect on number of umbel plant^{-1}.

Phosphorous levels					
Root size	**Control**	**50 Kg ha^{-1}**	**75 Kg ha^{-1}**	**100 Kg ha^{-1}**	**Means**
5 cm	49.6	52.3	56.3	60.9	54.8 d
10 cm	56.2	58.0	67.0	68.1	62.3 c
15 cm	64.7	66.9	68.4	73.3	68.3 a
20 cm	62.5	65.3	68.0	70.0	66.4 b
Means	58.2 b	60.6 b	64.9 a	68.1 a	

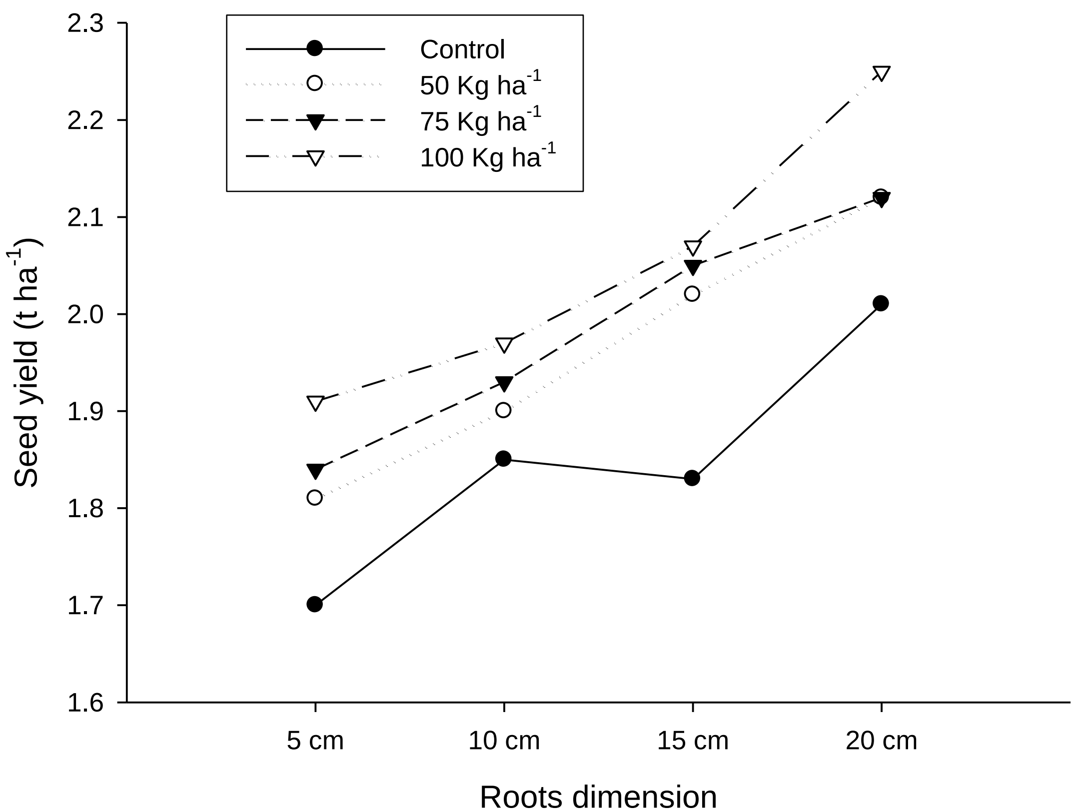

Fig. 4 Carrot seed yield (t ha^{-1}) as influenced by various roots dimension and phosphorus levels

Number of umbellate umbel^{-1}

Phosphorous level significantly increased in number of umbellate umbel^{-1}(NUU) while with low level of P fertilization decreased the NUU. Regarding root size, carrot with root size of 15 cm showed best results while both increase and decrease from 15 cm showed decrease in NUU.Using large root size of 15 cm with application of phosphorous @100 kg ha^{-1} promoted NUU.Increase in NUU may be due to the vigor of plant and more nutrients availability. The results of Tomer*et al*. (1994) who concluded that application of maximum amount of NPK ha^{-1} to coriander promoted increase in NUU are very important. Similarly Eid*et al.* (1992) reported that large roots produced maximum NUU. Many researchers reported that with no P fertilization, plant growth and development significantly reduced and effect the plant dry biomass and productivity which ultimately leading to food insurgency (Imran et al., 2020a; Imran et al., .2020b; Imran et al., 2019a; Ali et al., 2019). It has been reported that P is an important plant metabolism component and making 0.2% of the plant dry weight (Karim and Imran. 2019; Imran et al., 2018; Imran 2018a). Therefore P fertilization is needed as it is an important major plant nutrients after N. In limited P application or no P fertilization, plants cannot grow as it is a key component of nucleic acids, phospholipids and ATP and without these components plant cannot survive (Imran 2018b; Imran. 2018c; Imran 2018d). Phosphorus is involved in controlling and regulating several enzymatic function and reaction in metabolic pathway and thus regulating plant growth and development and ultimately plant productivity and yield (Imran and Amanullah. 2018; Imran. 2018e; Imran and Khan 2017). Other researcher reported that P is very rarely available in soil or only available in soil out of the rhizosphere which cannot support the plant for high growth rate and development (Amanullah et al., 2020; Imran et al., 2020c; Imran et al., 2017a). Phosphorus application is necessary in agriculture system to ensure crop productivity and food security (Imran et al., 2017b; Imran 2017; Imran et al., 2015a). Limited P supply in bulk soil effect P uptake by plants as it is only move by the process of diffusion and do not uptake or very low amount is uptake by the crop plants which is an alarming threat for low productivity (Imran, et al., 2015b; Imran,et al., 2019b).

Table 5: Root size and phosphorous effect on number of umbellate umbel^{-1} of carrot.

Phosphorous levels					
Stickling size	**Control**	**50 Kg ha^{-1}**	**75 Kg ha^{-1}**	**100 Kg ha^{-1}**	**Means**
5 cm	41.7	43.7	45.6	43.7	43.7 d
10 cm	51.9	56.3	58.7	63.3	57.6 c
15 cm	65.1	68.5	73.7	71.0	69.6 b
20 cm	58.6	62.2	64.8	65.3	62.7 a
Means	54.3 c	57.7 b	60.7 a	60.8 a	

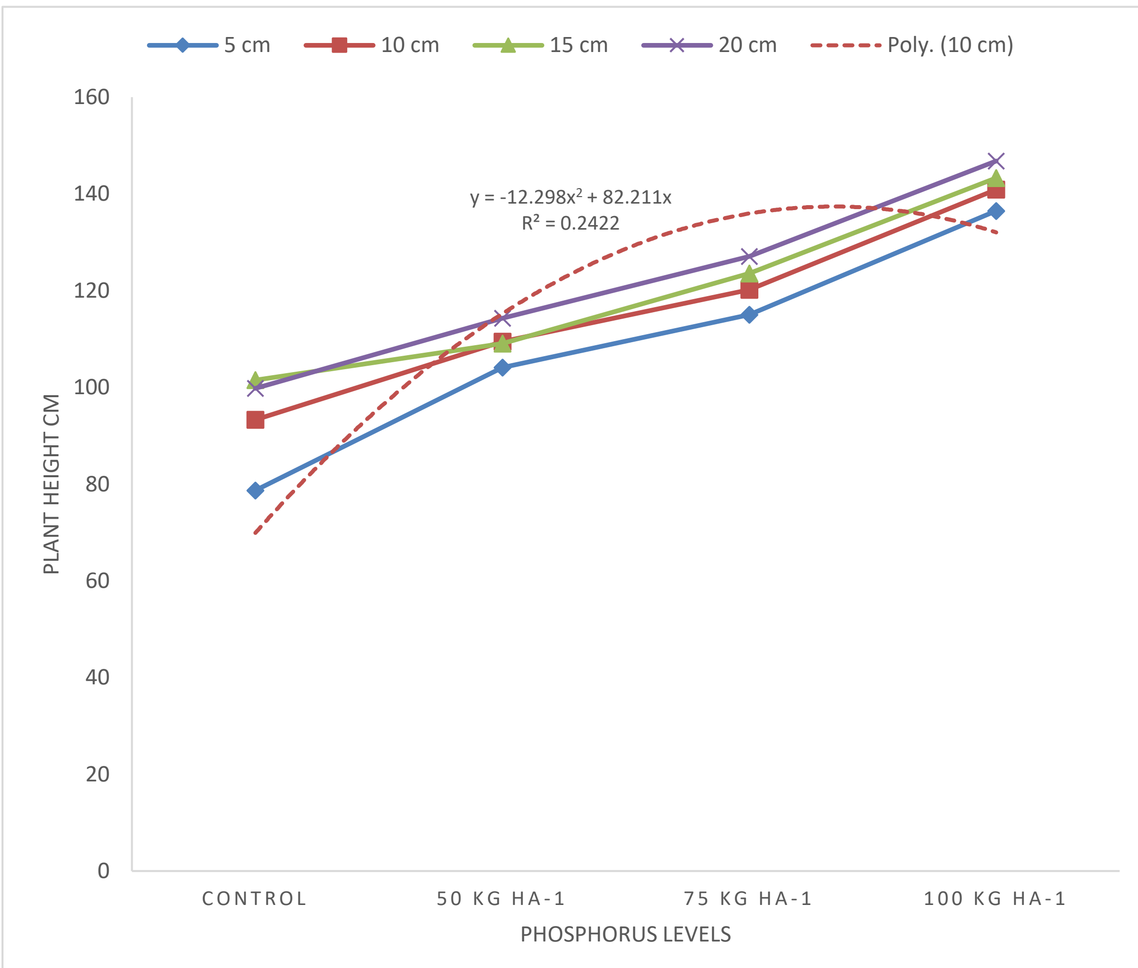

Fig. 5. Regression analysis of carrot plant height (cm)

Seed yield umbel^{-1} (g)

It is cleared from the data in (Table-6) that maximum seed yield umbel^{-1} was recorded in plants supplied with phosphorous @ 100 kg ha^{-1} that was less in control plants. Similarly root size of 20 cm produced more seed yield umbel^{-1},whereas least seed yield umbel^{-1} was recorded in plants of stickling size 5 cm (Fig. 3). It also obvious from the data that plants having big root size with the application of phosphorous @ (100 kg ha^{-1}) produced maximum seed yield umbel^{-1}. Phosphorous is an important part of phytin storage form of phosphorous in seed which increase seed size and weight and ultimately seed yield. My results are closely related with that of Sing *et al*. (1991) who reported that increasing Phosphorous levels increased 1000 seed weight. Akbar and Amjad (2002) reported that large size root and wider space resulted in maximum average seed weight per umbel in carrot as compared small size roots and small space. Phosphorus is involved in controlling and regulating several enzymatic function and reaction in metabolic pathway and thus regulating plant growth and development and ultimately plant productivity and yield (Imran and Amanullah. 2018; Imran. 2018e; Imran and Khan 2017). Other researcher reported that P is very rarely available in soil or only available in soil out of the rhizosphere which cannot support the plant for high growth rate and development (Amanullah et al., 2020; Imran et al., 2020c; Imran et al., 2017a). Phosphorus application is necessary in agriculture system to ensure crop productivity and food security (Imran et al., 2017b; Imran 2017; Imran et al., 2015a). Limited P supply in bulk soil effect P uptake by plants as it is only move by the process of diffusion and do not uptake or very low amount is uptake by the crop plants which is an alarming threat for low productivity (Imran, et al., 2015b; Imran,et al., 2019b).

Table 6. Root size and phosphorous effect on Seed yield umbel^{-1} (g) of carrot.

Phosphorous levels					
Root size	**Control**	**50 Kg ha^{-1}**	**75 Kg ha^{-1}**	**100 Kg ha^{-1}**	**Means**
5 cm	3.6	4.8	4.9	4.7	4.5 d
10 cm	5.4	6.0	6.5	6.7	6.2 c
15 cm	5.7	6.6	6.8	6.7	7.3 b
20 cm	6.7	7.5	7.9	7.7	6.6 a
Means	5.4 c	6.2 b	6.5 ab	7.4 a	

Seed yield plant^{-1} (g)

Mean data in (Table 7) showed significant effect of both phosphorous and root size on seed yield plant^{-1}. Application of phosphorous @ 100 kg ha^{-1} produced maximum seed yield plant^{-1}that decreases with decrease in phosphorous doze. Amongvarious root size seed yield plant^{-1}was high in plants of root size 20 cm, while less seed yield plant^{-1} was noted in plants of root size 5 in plants of root size 10 cm and 15 cm respectively. From the interaction of phosphorous and root size it is cleared that using large root of about 20 cm with the application of phosphorous @ 100 kg ha^{-1} produced maximum seed yield plant^{-1}as compared to other treatments. Increase in seed yield plant^{-1} depends on many yield contributing factors such number of umbel plant^{-1}, umbellate umbel^{-1} and seed yield umbel^{-1} which were maximum in large root size and maximum phosphorous level which has more store food and phosphorous has important role in fertility and nutrients availability so resulted in vigor plant growth. It has been reported that P is an important plant metabolism component and making 0.2% of the plant dry weight (Karim and Imran. 2019; Imran et al., 2018; Imran 2018a). Therefore P fertilization is needed as it is an important major plant nutrients after N. In limited P application or no P fertilization, plants cannot grow as it is a key component of nucleic acids, phospholipids and ATP and without these components plant cannot survive (Imran 2018b; Imran. 2018c; Imran 2018d). Phosphorus is involved in controlling and regulating several enzymatic function and reaction in metabolic pathway and thus regulating plant growth and development and ultimately plant productivity and yield (Imran and Amanullah. 2018; Imran. 2018e; Imran and Khan 2017). Phosphorus application is necessary in agriculture system to ensure crop productivity and food security (Imran et al., 2017b; Imran 2017; Imran et al., 2015a). Limited P supply in bulk soil effect P uptake by plants as it is only move by the process of diffusion and do not uptake or very low amount is uptake by the crop plants which is an alarming threat for low productivity (Imran, et al., 2015b; Imran,et al., 2019b). our results are in harmony with that of Kavak (1999) who reported that large stickling produce maximum seed plant^{-1} as compared to small ones. Also Sing *et al.*(1991) reported that seed yield plant^{-1} increased with maximum phosphorous application. My findings are closely related to those of Arya and Saini (1977), who observed an increase in seed yield of kg ha-1 by planting a large root in carrots. Root size and P effect on carrot seed yield (t ha-1).

Table 7. Root size and phosphorous effect on Seed yield plant^{-1} (g) of carrot.

Phosphorous levels					
Root size	**Control**	**50 Kg ha^{-1}**	**75 Kg ha^{-1}**	**100 Kg ha^{-1}**	**Means**
5 cm	55.8	71.6	75.7	78.0	70.3 c
10 cm	62.7	76.5	78.4	83.0	75.2 b
15 cm	72.0	78.0	77.4	83.3	77.6 b
20 cm	77.1	84.4	85.5	91.4	84.6 a
Means	66.9 d	77.6. c	79.3 b	83.9 a	

Seed yield plot^{-1} (g)

Mean data in (Table 8)revealed that higher seed yield plot^{-1} was produced in plants received 100 kg ha^{-1} while least Seed yield plot^{-1} (724.90 gm) was recorded in control plants. As for as root sizehigher yield plot^{-1} was obtained in plants of root size 20 cm, whereas least Seed yield plot^{-1} was recorded in plants of root size 5 cm followed by in plants of root size 10 cm and 15 cm respectively. The interactive effect of phosphorous and root size showed that Seed yield plot^{-1}was high in plants of roots size 20 cm with the application of phosphorous level @ (100 kg ha^{-1}) of stickling size 20 cm. The increase in seed yield might be due to variation in root size. Large root contain more store food which might be used for the production of vigor plant body with maximum number of umbels, umbellate and number of seeds as compared to small stickling size with less store food. Many researchers reported that with no P fertilization, plant growth and development significantly reduced and effect the plant dry biomass and productivity which ultimately leading to food insurgency (Imran et al., 2020a; Imran et al., .2020b; Imran et al., 2019a; Ali et al., 2019). Phosphorus is involved in controlling and regulating several enzymatic function and reaction in metabolic pathway and thus regulating plant growth and development and ultimately plant productivity and yield (Imran and Amanullah. 2018; Imran. 2018e; Imran and Khan 2017). Findings of (Wood *et al.,* 1994) are very important in this regard who reported that phosphorous is very essential for seed production and increase seed weight. It has been reported that P is an important plant metabolism component and making 0.2% of the plant dry weight (Karim and Imran. 2019; Imran et al., 2018; Imran 2018a). Therefore P fertilization is needed as it is an important major plant nutrients after N. In limited P application or no P fertilization, plants cannot grow as it is a key component of nucleic acids, phospholipids and ATP and without these components plant cannot survive (Imran 2018b; Imran. 2018c; Imran 2018d). Phosphorus application is necessary in agriculture system to ensure crop productivity and food security (Imran et al., 2017b; Imran 2017; Imran et al., 2015a). Limited P supply in bulk soil effect P uptake by plants as it is only move by the process of diffusion and do not uptake or very low amount is uptake by the crop plants which is an alarming threat for low productivity (Imran, et al., 2015b; Imran,et al., 2019b).

Table 8. Root size and phosphorous effect on Seed yield plot^{-1} (g) of carrot.

Phosphorous levels					
Root size	**Control**	**50 Kg ha^{-1}**	**75 Kg ha^{-1}**	**100 Kg ha^{-1}**	**Means**
5 cm	591.7	724.5	743.4	760.6	705.0 c
10 cm	667.3	769.2	759.2	785.7	745.4 b
15 cm	717.2	784.9	781.2	834.0	779.3 b
20 cm	777.3	855.2	860.2	896.3	847.3 a
Means	688.4 d	783.5 c	786.0 b	819.2 a	

Seed yield (t ha^{-1})

It is evident from the data in (Table 9) that plants with maximum application of phosphorous @ 100 kg ha^{-1} produced more seed yield (t ha^{-1}) than rest of the treatments. Maximum seed yield (t ha^{-1} was recorded in plants of root size 20 cm, that decreased with small root size (Fig. 4). For maximum seed yield large root size with application of phosphorous @ 100 kg ha^{-1} showed significant results. The increase in yield t ha^{-1} might be due to the difference in root size. Large root has more accumulated food than small ones, which affects the morphological characteristics of carrot. As growth and yield parameters such as number of leaves, length of leaves and production of branches in plant depends upon on stored food materials in roots. These parameters will be maximum with more stored food (Hamid *et al.*, 2002). The increase in yield of carrot by phosphorous application might be due to the role of phosphorous in improving soil fertility and increasing the nutrients availability which in result increase growth and yield parameters. It has been reported that P is an important plant metabolism component and making 0.2% of the plant dry weight (Karim and Imran. 2019; Imran et al., 2018; Imran 2018a). Therefore P fertilization is needed as it is an important major plant nutrients after N. In limited P application or no P fertilization, plants cannot grow as it is a key component of nucleic acids, phospholipids and ATP and without these components plant cannot survive (Imran 2018b; Imran. 2018c; Imran 2018d). Phosphorus is involved in controlling and regulating several enzymatic function and reaction in metabolic pathway and thus regulating plant growth and development and ultimately plant productivity and yield (Imran and Amanullah. 2018; Imran. 2018e; Imran and Khan 2017).Phosphorus application is necessary in agriculture system to ensure crop productivity and food security (Imran et al., 2017b; Imran 2017; Imran et al., 2015a). Limited P supply in bulk soil effect P uptake by plants as it is only move by the process of diffusion and do not uptake or very low amount is uptake by the crop plants which is an alarming threat for low productivity (Imran, et al., 2015b; Imran,et al., 2019b). The results of Sheikh *et al* (2000) are very crucial in this regard who reported that maximum seed yield kg ha^{-1} was obtained with application of maximum amount of phosphorous 150 kg ha^{-1} as compared to less amount of phosphorous in combination of basal dose of Nitrogen. Paradisi and Montanari (1985) observed increased in seed yield kg ha^{-1} by planting big size root in carrot. My findings are closely related to those of Arya and Saini (1977), who observed an increase in seed yield of kg ha-1 by planting a large root in carrots. Root size and P effect on carrot seed yield (t ha^{-1}).Other researcher reported that P is very rarely available in soil or only available in soil out of the rhizosphere which cannot support the plant for high growth rate and development (Amanullah et al., 2020; Imran et al., 2020c; Imran et al., 2017a).

Table 9. Root size and phosphorous effect on Seed yield (t ha^{-1}) of carrot.

	Phosphorous levels				
Root size	**Control**	**50 Kg ha^{-1}**	**75 Kg ha^{-1}**	**100 Kg ha^{-1}**	**Means**
5 cm	1.70	1.81	1.84	1.91	1.81 d
10 cm	1.85	1.90	1.93	1.97	1.92 c
15 cm	1.83	2.02	2.05	2.07	2.01 b
20 cm	2.01	2.12	2.12	2.25	2.13 a
Means	1.88 c	1.96 b	1.99 b	2.05 a	

CONCLUSION

It was concluded that phosphorus application is necessary in agriculture system to ensure crop productivity and food security. Phosphorus is involved in controlling and regulating several enzymatic function and reaction in metabolic pathway and thus regulating plant growth and development and ultimately plant productivity and yield. Both phosphorous and root dimension are vital for carrot growth and seed production. Large root of about 20 cm with phosphorous application @ 100 kg ha^{-1} resulted better growth and rigorous seed production in carrot cultivar 'Shan' under the climatic condition of Mansehra.

ACKNOWLEDGEMENT

The authors highly acknowledge the technical support of the ARF Hazara University administration, research team and scientist for their help and by provision of research facilities (research farm, inputs, labours, farm machinery etc) for the successful completion of this project.

CONFLICT OF INTEREST

All the authors declare that they have no conflict of interest.

REFERENCES

Akbar N., A. Iqbal, H. Z. Khan, M. K. Hanif and M.U. Basher. 2012. Effect of different sowing dates on the yield and yield component of direct seeded fine rice (*Oryza sativa* L.). J. Pl. Breed. Crop Sci. **2**(10): 312-315.

Arya, P. S and S.S. Saini. 1977. Effect of stickling size on seed yielding of carrot. Veg. Sci.4 (l): 6- l0.

Anjum, M. A and M. Amjad. 2002.Influence of mother root size and plant spacing on carrot seed production. J. Res. Sci. 13(2): 105-112.

Bangulzai, N. A.1990. Effect of different levels of nitrogen and potassium on the growth and yield of carrot (DaucusCarrota L.).Tandojam Sindh Agriculture University, MSc Thesis.

Baloch, A. F. 1994. Vegetable crops.Horticulture .National Book Foundation.Manza printing corporation Islamabad.p.469.

Bujdoso, C and I. Hrasko.1983. Evaluation of carrot stickling raised in the growing room and in the field for seed production.Zol d-seyternesztesi ' kutatointezetBuiletinje l6: 109-.l14. (c.f. Hort.Abstr, 54, 3681, l9B4).

Eid, S. M. M and F. A. A. Sedera.1992. Effect of foliage cutting and, GA3 foliar spray on carrot flowering, root size, yield and quality. Assiut.J.Agri.Scie. 23(2).

Gill, S. S., B. S. Gill, S. P. S. and B. Singh. 1995. Nitrogen and phosphorus requirement of radish seed crop. Seed Research. 23(1): 47 – 49.

Hamid, A., Z. A. Shah and M. Asif. 2002. Seed Yield Performance of Radish Depending on Stickling Size under the Sub-tropical Conditions of Azad Kashmir. Agri. J. Plant Sci. 1 (6): 636-637.

Kavak, T. S. 1999. Effect of root size on yield and quality of carrot (Daucuscarota L.) seeds Turkish National Horticultural Congress. (Ankara Univ., Faculty of Agriculture, Ankara (Turkey). Div. of Horticulture) - ISBN 975-482-484-3. P.1058..

Mishra, H. P. 1987. Effect of NPK on Growth, Seed Yield and Quality of Radish Cv. PusaRashmi Grown in the Calcareous Soils of North Bihar.Ind. J. Hort. 44 (1-2): 69- 73.

Paradisi, U and M. Montanari. 1985. The effect of plant density and steckling size on the yield of carrot seed, SementiElette. Hort. Abst. 56(7): 5359.

Sharma, A. K. 2000. Effect of nitrogen and phosphorus on seed yield in radish (Raphanussativus L). Agri. Sci. Digest. 20 (1): 46- 49.

Sheikh, M. T., G. H. Jamro,N. A. Shah, F.Rehman F 2000. Effect of nitrogen and phosphorus combinations on seed production of turnip, Brassica rapa (L.) under Quetta conditions. Baloch. J. Agri. Scie. 1(2): 12-14.

Singh, H., S. S. Gill, B. S. Gill, S. P.S. Brarand,B. Singh. 1991. Yield and qualityof carrot seed as influenced by nitrogen and phosphate fertilization. J.Res. Punjab Agricultural University. 28: 483 – 488.

Tomar, V. K., R. K. Bhatnagar and R. K. Palta. 1998. Effect of vermicompost on production of brinjal and carrot. BhartiyaKrishi AnusandhanPatrika. 13(3-4): 153-156.

Wood, C. W., W. L. Kingery,D. P. Delaney, J.C. Williams and G. L. Mullins. 1994. Impact of long-term land application of broiler litter on environmentally related soil properties. J. Environ. Qual. 23: 139-147.

Imran, Amanullah, Muhammad Arif, Zahir Shah and Abdul Bari. 2020a. Soil application of *Trichoderma*and Peach (*Prunuspersica* L.) residues possesses biocontrol potential for weeds and enhances growth and profitability of soybean (Glycine max). Sarhad Journal of Agriculture 36 (1) 10-20.

Imran, Amanullah, Abdel Rehman Al-Tawaha.2020b. The Productivity of subsequent wheat enhanced with residual carbon sources and phosphorus under improved irrigation system. (Accepted) Communication in soil science and plant analysis.

Imran, Amanullah, A.A Khan, Abdul bari. 2019. Production statistics and modern technology of maize cultivation in Khyber Pakhtunkhwa Pakistan. Plant sci. Arc.2 (2) 1-12

Izhar, Ali, Asad Ali Khan, Imran, inamullah, Aman Khan. 2019. Humic acids and Nitrogen levels optimizing productivity of green gram (vigna radiate L.). Russian Agriculture Sciences, 45(1), 43-47.

Syed Arshad Karim and Imran. 2019. Reduction in substrate moisture content reduce final yield of wheat. Biomed J. Sci& Tec Res. 1-5.

Imran, Amanullah, A. Bari and R. Ali. 2018. Peach sources, phosphorous and beneficial microbes enhance productivity of soybean. Soy. Res.16(2): 39-48.

Imran 2018a. Climate Change Is Threat toward Agronomy (Base of Food, Fiber System), and Food Security. Food Nutr J: FDNJ-160. DOI: 10.29011/2575- 7091. 100060

Imran 2018b. Physiological and Morphological Traits of Agronomic Crops Influenced By Climate Change. Mod ConcepDevAgrono.1(4). MCDA.000524.

Imran. 2018c. Ecological Environmental Variability Influence Growth and Yield Potential of Rice under Northern Climatic Scenario. Russian Agricultural Sciences, 2018, Vol. 44, No. 1, pp. 18–24.

Imran 2018d. Phosphorous fertilization influenced weeds attributes Andphenological characteristics Of mungbean cultivars (vignaradiata l.) Russian Agricultural Sciences, 2018, Vol. 44, No. 3, pp. 229–234.

Imran and Amanullah. 2018. Review. Global impact of climate change on water, soil resources and threat towards food security: evidence from Pakistan. Adv Plants Agric Res. 2018;8(5):350–355. DOI: 10.15406/apar.2018.08.00349

Imran. 2018e. Organic Matter Amendments Improve Soil Health, Productivity and Profitability of Maize and Soybean. Ann Rev Resear. 1(3): 555564.

Imran and Khan, A. A. (2017). Canola Yield And Quality Enhanced With Sulphur Fertilization Russ. Agricult. Sci. 43: 113 10.3103/S1068367417020100

Imran, Nasar Jamal, AshfaqAlamAndAsad Ali Khan. 2017a.Grain Yield, Yield Attributes Of Wheat And Soil Physio-Chemical Charicteristics Influenced By Biochar, Compost And Inorganic Fertilizer Application. Agri Res & Tech: Open Access J. DOI: 10.19080/ARTOAJ.2017.10.555795

Imran, Abdul Bari, Roshan Ali, Naeem Ahmad, Zulfiqar Ahmad, Muhammad IdreesKhattak, Akhtar Ali, Fayaz Ahmad, Inayatullah Khan And Shahida Naveed. 2017b. Traditional Rice Farming Accelerate CH4 &N2O Emissions Functioning As A Stronger Contributors Of Climate Change. Int J Environ Sci Nat Res. 2017; DOI: 10.19080/ARTOAJ.2017.09.555765

Imran. 2017. Climate Change Is a Real Fact confronting to Agricultural Productivity. Int J Environ Sci Nat Res. 2017; 3(3): 555613. DOI: 10.19080/IJESNR.2017.03.555613.

Imran, A. A. Khan, I. Ullah, H. zada, F. Ahmad, S.T. Shah, A. Usman and I. Ullah. 2015a. Yield and yield attributes of rapeseed cultivars as influence by sulfur level under swat valley conditions. J. Pure & Applied biology Vol. 4, Issue 3.

Imran, Shahida Naveed, Asad Ali Khan and Inayat Khattak. 2015b. Impact Of Phosphorus Levels And Seed Rates On Growth And Yield Of Late Sown Maize On High Elevation In Swat, Pakistan. Pakistan J. Agric. Res. Vol. 28 No. 4:406-413.

Imran, Amanullah, Abdul Bari, Hamayoun Khan and Roshan Ali. 2019. Climatic Variability and Agronomic Cropping Pattern. Springer Book, (Vol, 1) (Production technology) Agronomic crops.doi.org/ 10.1007/978-981-32-9151-5_3.

Imran. 2019. Advance production Technologies of legume crops. Springer Book (Vol, 1) (Production technology) Agronomic crops.doi.org/ 10.1007/978-981-32-9151-5_16.

Imran. 2019. Plant microbe's interaction in Agronomic crops. Springer Book (Vol, 2) (Management Practices) Agronomic crops.doi.org/ 10.1007/978-981-32-9151-8_21.