Research Article

Response of cauliflower (*Brassica oleracea* L. botrytis) cultivars to phosphorus levels

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Citation

Ehsan Elahi, Asif Wali, Nasrullah, Gohar Ayub, Saeed Ahmed, Zelle Huma and Nazeer Ahmed. Response of cauliflower (*Brassica oleracea* L. botrytis) cultivars to phosphorus levels. Pure and Applied Biology Vol. 4, Issue 2, 2015, pp 187-194.

Received: 28/02/2015

Revised: 19/04/2015

Accepted: 28/04/2015

Abstract

Cauliflower is one of largely produced vegetable in however low per hectare yield is a major problem. While improper and less frequent use of high yielding cultivars may be one reason, inadequate and unbalanced doses of fertilizer may be another important constraints leading towards lower yield of vegetable in Pakistan. So, this experiment was conducted to investigate the response of cauliflower cultivars to phosphorus levels, at Horticulture Farm, University of Agriculture, Peshawar. Randomized Complete Block Design was designed with split plot arrangement having two factors i.e., phosphorus levels (0, 40, 60, 80 kg ha⁻¹) and cauliflower cultivars (Peshawar local, Silver Star, White Diamond, White King), which were repeated thrice. It was found that Cauliflower cultivars and phosphorus levels significantly affected growth and yield parameters. The results revealed that maximum number of leaves plant⁻¹ (25.13), days to curd initiation (104), curd diameter (30.64 cm), curd weight (800 g) and yield ha⁻¹ (27.55 tons) were recorded at phosphorus level of 80 kg P₂O₅ ha⁻¹, while lower value for all parameters were observed in control plots. Among cultivars, White King showed maximum number of leaves plant⁻¹ (23), days to curd initiation (104), curd diameter (30 cm), curd weight (793 g) and yield ha⁻¹ (19 tons). As the interaction between phosphorus levels and cauliflower cultivars concerned, most of the growth and flowering attributes of cauliflower performed maximum results when cultivar White King was treated with 80 kg P₂O₅ ha⁻¹. It was concluded that application of phosphorus @ 80 kg ha⁻¹ and cultivar White King showed maximum results regarding yield, and hence recommended for Peshawar growers.

Key words: *Brassica oleracea* var. Botrytis L; response; cultivars; phosphorus; levels.

Introduction

Cauliflower (*Brassica oleracea* L. botrytis) commonly called Phool Gobi, belongs to the Brassicaceae (mustard) family. Its name comprised of two Latin words i.e. caulis, meaning cabbage and floris, meaning flower. Another distinctive name is queen of winter vegetable. Its leaves were eaten probably by half civilized people, when its cultivation started, the plant begin to produce dense rosettes or head of leaves [1]. Of all mustard family, cauliflower has the most exciting climatic requirements. Cauliflower is a cool-season annual crops that grow best at day time. The temperature requirement is 17°C and 18°C. The temperature above 20°C during maturity badly affects its growth. The best soil condition is sandy loam and silty loam. Cauliflower is sensitive to high acidity and grows best on a neutral to slightly acid soil, with pH 6.0-6.8 [2]. Cauliflower was discovered in the Mediterranean Sea from the wild cabbage over 2000 years ago. It is native to coastal regions of European, African and reported that first cauliflower was cultivated in India in year 1822 [3]. Pakistan is among top ten in production of cauliflower in the world. The total land under cultivation for cauliflower is 12,381 hectares of harvested area, which accounts for 18.38 tones ha⁻¹ of yield and 227,591 tons of production in 2010-11 [4]. In Khyber Pakhtunkhwa (KPK) province of Pakistan, cauliflower production was 14,800 tons from cultivated area of 1,297 hectares. In KPK, the average yield per hectare was 11.41 tons [5]. The increase in yield hectare is attributed to many factors however primarily on account of better specialized production practices. The average per hectare yield of Peshawar areas is far below than other parts of the country. This low yield could be related with imbalance dose of fertilizer and inadequate use of low

yielding cultivars. The current research was conducted to evaluate the response of selected cauliflower cultivars to different phosphorus levels on the growth and yield of cauliflower. It is therefore, imperative to examine the optimum level of phosphorus level and use of high yielding cultivars.

Materials and Methods

This research experiment “Response of cauliflower cultivars to phosphorus levels” was conducted at Horticulture Farm, Khyber Pakhtunkhwa, University of Agriculture, Peshawar, during 2011-12. The experiment was laid out in Randomized Complete Block Design (RCBD) with split plot arrangement having three replications as shown in Figure 1. Phosphorus levels were kept in main plot, while cultivars in sub plot. The row to row and plant to plant distance was kept as 60 cm and 30 cm, respectively. Urea applied at the rate of 120 Kg per hectare, half dose applied at the time of transplantation and half was applied after 45 days of transplantation. There were eight (8) plants of each cultivar in each treatment and the sub plot area was 1.44m². Single Super Phosphate (SSP) was taken as a source of phosphorus and applied at levels of 0, 40, 60, 80 kg ha⁻¹ in the experiment. The seeds of cauliflower cultivars; Peshawar Local, White Diamond, White King, and Silver Star were obtained from local market of Peshawar.

Factor A (Phosphorus levels, kg ha⁻¹) Factor B (Cultivars)

Main plot	Sub plot
1. P1 0 (Control)	1. Peshawar Local
2. P2 40	2. White Diamond
3. P3 60	3. White King
4. P4 80	4. Silver Star

Soil characteristics of the experimental field as evaluated in lab.

Soil texture class:	Silt loam
Nitrogen Percentage:	0.15 %
Phosphorus:	3.38 mg kg ⁻¹

Potassium	60 mg kg ⁻¹
Organic matter percentage	0.85 %
pH	7.71

Raising of nursery, transplanting of seedlings and losses due to transplantation

The seeds of all four cauliflower cultivars were sown separately in pods on October 2011. Well rotten farm yard manure was applied and mixed well before sowing. At three to four stage of seedling, water was reduced to twice weekly. Then seedlings were transplanted from the nursery beds to the field in the second week of November 2011. Healthy seedlings of uniform size were selected for transplantation. The seedlings were planted on one side of the ridge and were spaced at 60 cm row to row and 30 cm plant to plant. After one week of transplantation, a few dead seedlings were replaced by planting fresh seedlings, to obtain a uniform stand.

The following parameters were studied and data were recorded on them.

Number of Leaves Plant⁻¹

Number of leaves per plant was recorded by counting the number of leaves of five randomly selected plants and the number of leaves per plant was calculated.

Days to curd initiation

The crops were regularly observed to know the performance of different cultivars for curd initiation. The data was obtained by counting the number of days from the date of transplanting to the appearance of curd and was presented in days.

Curd diameter (cm)

The diameter of cauliflower curd in five randomly selected plants of each cultivar was measured. The diameter was taken in centimeter, from which diameter of curd per plant in each sub plants were recorded. The diameter of cauliflower was measured at the point of maximum width from two different sides.

Curd weight (g)

The weight of curd was recorded by weighing curd of five randomly selected plants and curd weight per plant in each sub plot was calculated.

Yield (tons ha⁻¹)

To estimate the yield per hectare, the yield of each sub plot was converted into yield per hectare by using the formula:

$$Yield\ tons\ ha^{-1} = \frac{Yield\ of\ plot\ (kg)}{Plot\ area\ m^2} \times 10000\ m^2$$

Statistical Analysis

The data recorded was analysis statistically according to the Randomized Complete Block Design (RCBD), with split plot arrangement by using a statistical package MSTATC [6].

Results and Discussion

These experiments were conducted to determine the response of cauliflower cultivars to phosphorus levels and the results observed are discussed below.

Number of leaves plant⁻¹

The data regarding number of leaves plant⁻¹ are shown in Table 1. Mean maximum values of number of leaves plant⁻¹ (25.13) were recorded for 80 kg ha⁻¹ phosphorus and the less number of leaves plant⁻¹ (17.10) for control treatment plants. Mean values for cultivars indicated that maximum number of leaves plant⁻¹ (23.08) were observed for cultivar of White King, which was statistically variation from the rest of the cultivars, followed by (20.32), whereas less number of leaves plant⁻¹ (17.38) in control treatment plants. The interaction of cauliflower cultivars and phosphorus levels depicted non-significant effect on number of leaves of cauliflower cultivars. The maximum number of leaves per plant (27.87) was recorded in the plants received by 80 kg ha⁻¹ in combination, but minimum number of leaves plant⁻¹(14.87) was noticed

in 40 kg ha⁻¹ by application of phosphorus. The possible reason would be that variation in number of leaves were linked with internodal length, because each cultivar had its own genetic background. Significant variation with regards to number of leaves was noticed among different treatments combination. Phosphorus had significantly influenced the number of leaves per plant⁻¹. [7] Reported that higher dose of phosphorus gave positive response in increasing the number of leaves. The findings clearly

suggested that 250 kg ha⁻¹ of phosphorus is essential for obtaining the highest number of leaves in cauliflower. [8, 9] also reported that treatments of nitrogen, phosphorus and potassium substantially enhanced plant vegetative growth. The current study results indicated that when the vegetative growth was enhanced, it favored the synthesis of necessary compounds protein and carbohydrate metabolism. So, these compounds are needed for growth of cauliflower curd.

Table 1. Effect of different phosphorus levels on number of leaves per plant of cauliflower cultivars

Cultivars	Phosphorus (kg ha ⁻¹)				Mean
	Control	40	60	80	
Peshawar Local	15.60	14.87	17.23	21.83	17.38c
White Diamond	16.00	17.67	23.47	24.13	20.32b
White King	19.80	20.67	24.00	27.87	23.08a
Silver Star	17.00	18.77	18.53	26.67	20.24b
Mean	17.10c	17.99c	20.81b	25.13a	

LSD value at 5% for cultivars = 2.8210; LSD value at 5% for phosphorus = 3.9645

Days to curd initiation

The analysis of data shows that phosphorus and cultivars had significant ($p < 0.01$) effect on time to curd initiation, while their interaction was non-significant (Table 2). It was revealed that maximum day to curd initiation was recorded for 60 kg phosphorus ha⁻¹ in Silver Star. However, mean value of cultivars showed that better response was recorded (104) by cultivar Silver Star which was statistically different from the rest of the cultivars, followed by (111), and whereas more time to curd initiation (115) was recorded in control conditions. The interaction for mean value between cultivars and phosphorus as significant effect on days

to curd initiation of cauliflower cultivars. Furthermore, less days to curd initiation (99) days was noted in the plants fertilized with phosphorus at the rate 60 kg ha⁻¹, whereas more time to curd initiation (121) noticed in control condition. Phosphorus is essential for general health and vigor of plants. Adequate availability of phosphorus improves flower formation, fruiting and early curd initiation. Phosphorus had significant effect on the days required to curd initiation [10]. Similarly, the finding indicated that phosphorus might have retarded vegetative growth and force plants to reach reproductive stages. [11, 12] found that application of phosphorus hastened the crop to reach reproductive stage which is an

agreement with the finding of present work. According to [13] that most of the characters like time to curd initiation, days to central head, plant frame, head size, head, harvest

duration and optimum head yield of broccoli were favored by applying 90 kg nitrogen and 90 kg phosphorus per hectare.

Table 2. Effect of different phosphorus levels on days to curd initiation of cauliflower cultivars

Cultivars	Phosphorus (kg ha ⁻¹)				Mean
	Control	40	60	80	
Peshawar Local	121	119	112	108	115 ^d
White Diamond	117	106	102	107	108 ^b
White King	119	105	105	105	111 ^c
Silver Star	111	104	99	104	104 ^a
Mean	117 ^c	111 ^b	104 ^a	106 ^a	

LSD value at 5% for cultivars = 2.064; LSD value at 5% for phosphorus = 2.447; LSD value for interaction at level 5% = 2.06

Curd diameter (cm)

The statistically analysis of data pertaining to curd diameter showed significant effect by the application of different phosphorus levels and cultivars. The interaction between cultivars and phosphorus was non-significant (Table 3). The data verified that maximum diameter of curd was recorded (30.64 cm) by the application of 80 kg ha⁻¹ which was statistically different from rest of the treatment, whereas lowest diameter was found in control condition. The cauliflower cultivars showed significant variation in curd diameter. The data regarding cultivars revealed that better response was recorded (32 cm) in White King, while less diameter of curd (25.18 cm) was recorded in Peshawar Local. Interaction between phosphorus and cultivars demonstrated significant effect on curd diameter of cauliflower. However, more diameter of curd (33.50 cm) was found in the plants receiving fertilizer 80 kg ha⁻¹ in combination, whereas less diameter of curd

(23.83cm) was noticed in control condition. Maximum diameter of curd at fertilizer level 120, 70, 90 kg NPK/ha might be due to increase in water content and accumulation of reserved substances in the leaves resulting from increasing supply of N, P and K. The results are similar to that of [11] who also reported maximum head diameter in cabbage at high fertilizer level. Diameter of cauliflower curd has important value for marketable yield [14]. The increasing curd diameter application as a result of optimum fertilizer dose and improved available nutrient status of soil results in plant vigor and also increase helps leaves production.

Curd weight (g)

From analysis of data it was revealed that curd weight had significant effect by the application of different level of phosphorus and cultivars, while their interaction was non-significant (Table 4). According to mean values of phosphorus levels, confirmed that maximum curd weight was

Table 3. Effect of different phosphorus levels on curd diameter (cm) of cauliflower cultivars

Cultivars	Phosphorus (kg ha ⁻¹)				Mean
	Control	40	60	80	
Peshawar Local	23.83	24.30	26.50	26.10	25.18 ^c
White Diamond	24.00	25.96	27.19	32.69	27.46 ^b
White King	30.30	31.70	32.50	33.50	30.00 ^a
Silver Star	24.66	26.54	26.17	30.28	26.91 ^b
Mean	27.70 ^c	27.13 ^{bc}	28.09 ^b	30.64 ^a	

LSD value at 5% for cultivars = 2.064; LSD value at 5% for phosphorus = 2.447; LSD value at 5% for interaction = 2.046

recorded (800 g) by the application of 80 kg ha⁻¹ which was statistically significant whereas lowest curd weight was recorded in control condition. The mean value of cultivars found that White King responded better (793 g) which was statistically different from the rest of the cultivars, followed by (776 g), whereas less curd weight (723 g) recorded in control plants. Interaction between phosphorus and cultivars presented a non-significant effect on curd weight in cauliflower. However more curd weight (820 g) was noted in the plants receiving fertilizer with 80 kg ha⁻¹ in combination, whereas less curd weight (670 g) was noticed in control condition. The curd weight of cauliflower had supported by application of phosphorus and also genetic potential of cultivars. Most favorable level of phosphorus fertilizer application improved the vegetative and reproductive growth of cauliflower. The phosphorus had significant influence on curd weight of cultivars. The curd weight was increased considerably by increasing the application of fertilizers. These above results are in line with the result of [10] who reported that more plant curd weight was seen in the plant which received finest level of phosphorus.

The previous researcher [15] also documented that phosphorus is vital nutrient, as it is the structural part of various compounds, phospholipids and many co enzymes.

Yield hectare⁻¹ (tons)

The data pertaining to yield ha⁻¹ is shown in Table-5. According to mean values of phosphorus determined that the maximum yield ha⁻¹ (26.79 tons ha⁻¹) was recorded in the plants receiving 80 kg phosphorus, which was significant followed by (25.94 tons ha⁻¹) in 60 kg treatment, while the minimum yield (22.16 tons ha⁻¹) was obtained in untreated plants. Cauliflower cultivars significantly influenced the yield ha⁻¹. Regarding to mean values of cultivars maximum yield ha⁻¹ (27.62 tons ha⁻¹) was recorded in cultivar White King, which was significant followed by Silver Star (25.69), while the minimum average yield ha⁻¹ (21.76 tons ha⁻¹) was recorded in Peshawar local. Main objective of the study of any crop is to get maximum production. So many factors which can affect the crop yield from sowing to harvest. Environmental factors, genetic makeup and soil structure influence the yield. The results from the study clarified that the highest phosphorus

Table 4. Effect of different phosphorus levels on curd weight (g) of cauliflower cultivars

Cultivars	Phosphorus (kg ha ⁻¹)				Mean
	Control	40	60	80	
Peshawar Local	670	710	740	770	723 ^d
White Diamond	700	760	780	800	760 ^c
White King	750	790	810	820	793 ^a
Silver Star	730	780	785	810	776 ^b
Mean	713 ^c	760 ^b	779 ^b	800 ^a	

LSD value at 5% for cultivars = 16.727; LSD value at 5% for phosphorus = 18.236

levels produce large diameter of curd and curd weight. Phosphorus play a key role in metabolism and photosynthesis, additional, it is more important component of phospholipids and nucleic acid [16]. [17] Verified that addition of the soil nutrients can promote plant growth which increases the photosynthetic and digestion rates. An experiment [18] to find out effect of nitrogen and phosphorus levels on the performance of broccoli. Combined application of 100 kg N+80 kg P₂O₅/ha produced the highest biological yield per plant; curd yield per plant and per hectare. The above results are supported by the finding of [19] who found that yield and chemical composition are related with the

vigorous growth which is correlated with proper nutrition. Yield is significantly affected by the optimum levels of phosphorus. Phosphorus is an essential element for general health and vigor of plants. Adequate availability of phosphorus stimulates root development, increase stalk and stem length and improve flower formation.

Conclusion

It is concluded on the basis of performed experiment at the location at Horticulture Research Farm, The University of Agriculture Peshawar, that phosphorus application at the rate of 80 kg ha⁻¹ and cultivar White King could be optimum for growth and for maximum yield of Cauliflower.

Table 5. Effect of different phosphorus levels on yield per hectare (tons) of cauliflower cultivars

Cultivars	Phosphorus (Kg ha ⁻¹)				Mean
	Control	40	60	80	
Peshawar Local	19.90	21.69	22.22	23.37	21.70 ^d
White Diamond	20.90	24.07	25.92	26.77	24.42 ^c
White King	25.23	27.31	28.77	29.16	27.62 ^a
Silver Star	22.60	25.46	26.85	27.28	25.69 ^b
Mean	22.16 ^d	24.53 ^c	25.94 ^b	26.79 ^a	

LSD value at 5% for cultivars = 1.853; LSD value at 5% for phosphorus = 0.8841

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