



Research Article

Effect of Organic Fertilizers on Potato Cultivars in Parachinar (District Kurram), Pakistan

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Abstract | To find out the effect of organic fertilizer on potato cultivars, an experiment was conducted at Horticulture Nursery Farm, Agriculture Department Parachinar, Kurram Agency, Pakistan in 2023-024. The experiment consists of two factors including organic manures (Leaf mold, Farmyard manure and Poultry manure), at the rates of 10 tons ha⁻¹ each, and control treatment, with three potato cultivars (Burna, Desiree and Cardinal). The experiment was laid out in a Randomized Complete Block (RCB) design with three replications. Both organic fertilizers and cultivars significantly affected potato growth and quality. Among all the organic fertilizers, Leaf-Mold fertilizer showed maximum sprouting percentage (57.77 %), number of tuber plant⁻¹ (5.22), tubers weight plant⁻¹ (0.659 g), tuber diameter (3.28 cm), tuber yield ha⁻¹ (25.57 tons) and minimum days to emergence (17.44 days). Among the three cultivars, Desiree showed maximum sprouting percentage (62.08 %), number of tubers plant⁻¹ (4.58), tuber weight plant⁻¹ (0.55 g), tuber diameter (2.970 cm) tuber yield ha⁻¹ (25.01 tons) and minimum day to emergence (19.08 days) from the soil. From the results, it was concluded that Leaf mold fertilizer showed better results therefore, Leaf mold fertilizer at the rate of 10 tons ha⁻¹ is recommended for potato farming and among three potato cultivars, Desiree showed better performance in the selected area therefore Desiree is recommended for the agro-climatic conditions of Parachinar, Kurram agency.

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Keywords | Organic fertilizers, Potatoes cultivars, Desiree, Poultry manure, Leaf mold



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Introduction

Potato (*Solanum tuberosum* L), belongs to Solanaceae (nightshade) family, it fulfils food require-

ments in most parts of the world, just like other crops. Potato is the most famous salad crop in the world and an important member of the field crops. It is not only used locally but also transported to other parts

of the world and plays an important role in enhancing foreign exchange. (Kandil *et al.*, 2011). Potato is now the world's third most important food crop in terms of human consumption, after wheat and rice (Devaux *et al.*, 2021). Potatoes contain starch, protein, vitamins and micronutrients like iron and zinc. In developing countries, potatoes also referred to as hidden hunger due to their role in exacerbating micronutrient deficiencies, which is a significant global public health issue impacting approximately 2 billion people worldwide (Bailey *et al.*, 2015).

In Pakistan, potato was cultivated on 314125 hectares and produced 7936884 tons potato 2021-22. In KPK, during 2021-22, the potato was produced on 11626 hectares with a total production of 166123 tons. During 2021-22, potato was produced on 468 hectares with a total production of 7951 tons in District Kurram (Anonymous, 2022). Some of the well-known varieties grown in Parachinar are Red skin varieties (Cardinal, Desiree, Ultimas) and white skin varieties (Multa, Ajax and Spuntaa). Potato production was hindered for a long time due to various reasons like non-availability of quality tubers, high prices and poor handling of fertilizers, less or no use of organic fertilizers and low market value during the time of harvesting. All organic and inorganic fertilizers play an important role in the production of different vegetables, especially potatoes. and organic fertilizer increased potato yield by 43-45% (Gelaye, 2023).

Nowadays there is a gradual deficiency in soil organic matter due to the exhaustive cropping system of Pakistan, and due to high fertilizer prices, the use of fertilizer declined sharply. Organic fertilizer is a good alternative, available easily to farmers at a low cost as compared to inorganic fertilizer. Previous studies have reported that biological organic fertilizer improves soil quality and soil enzyme activity and increases the activity of functional microorganisms, as well as effectively inhibits soil-borne diseases and promotes plant growth (Li *et al.*, 2017). The application of bio-organic fertilizers also improved soil fertility, increased bacterial diversity, and reduced fungal diversity (Li *et al.*, 2021).

Mostly pathogenic soil organisms are suppressed by the organic fertilizer which also helps in the degradation of toxic organic chemicals and stimulates microbial activity around the root system significantly (Ali *et al.*, 2009). It protects against the diseases associated

with numerous fungi and in some environments; they produce peptides which inhibit the growth of fungi. Potatoes contain carbohydrates and are rich in vitamin C. Potatoes are used for skin and hair diseases.

Organic fertilizer contains nitrogen in sufficient amounts; it helps to increase the soil porosity and aeration and also improves the soil structure (Ahmad *et al.*, 2023). Organic fertilizer increases the water-holding capacity which helps in production and is also beneficial to microbial growth (Leytem and Westermann, 2005). Aluko *et al.* (2005) observed good results of potato growth on poultry manure at a level of 8-10 tons ha⁻¹. Raupp *et al.* (2001) concluded that farmyard manure not only brings changes in crop growth but also improves the soil conditions and maintains its fertility from their long-term experiment on different types of crops every year and application of farmyard manure fertilizer treatments.

To examine the effect of organic fertilizer (FYM, poultry manure and Leaf mold) on potato cultivars. To find out the best potato cultivar for the farming community of District Kurram Parachinar.

Materials and Methods

The experiment "Effect of organic fertilizer on potato cultivars." under the climatic conditions of Kurram Agency, Parachinar was conducted at Horticulture Nursery Farm, Agriculture department in 2023.

The experimental soil was silty clay loam in texture, almost neutral in reaction, nonsaline and calcarious in nature and deficient in organic matter, exchangeable potassium and available boron. The details are mentioned in Table 1. The land was prepared three weeks before sowing with the help of different instruments and suitable moisture was maintained. Well-decomposed organic fertilizers were applied at the time of land preparation. All cultivars of potatoes were purchased from the research station. The specified land was divided into three main plots having an area of 23.29 m² and sub-plots each having an area of 7.56 m². The row-to-row distance was 60 cm and plant to plant distance was 30 cm.

The experiment was carried out in a Randomized Complete Block (RCB) design with 2 factors arrangement and each treatment was replicated three times.

Factor A = Organic fertilizer 10 (ton ha⁻¹)

T₀ = Control, T₁ = Farmyard manure

T₂ = Poultry manure, T₃ = Leaf compost

Factor B = Potato cultivars

C₁ = Cardinal, C₂ = Desiree, C₃ = Barna

All cultural practices such as weeding, hoeing, irrigation and earthing up were practised uniformly for all the treatments and data was recorded on randomly selected plants for the following parameters.

Table 1: Physico-chemical characteristics of the experimental soil.

Property	Unit	Value
Clay	%	32.00
Silt	%	53.50
Sand	%	14.50
Soil texture	%	Silty clay loam
pH (1:5)	-	7.40
E.C (1:5)	dSm ⁻¹	0.16
Organic matter	%	0.81
CaCO ₃	%	8.80
Potassium	mg kg ⁻¹	68.00
Boron	µg kg ⁻¹	0.40

Sprouting percentage

Sprouting tubers percentage was calculated by the formula:

$$\text{Sprouting percentage of tubers} = \frac{\text{Number of sprouted tubers}}{\text{Total number of tubers}} \times 100$$

Days to emergence

The emergence period was determined from the date of sowing to the date of emergence.

Number of tubers plants⁻¹

The numbers of tubers plant⁻¹ were counted in each treatment and an average number of tubers plant⁻¹ was noted.

Tuber weight plants⁻¹ (kg)

The potato tubers plant⁻¹ was recorded in each experimental plot with a digital balance and the average weight of tubers was noted.

Tuber diameter (cm)

The tuber diameter was measured by using a venire calliper and calculated their average data by the mean

formula of selected plants and the average tuber diameter was recorded in centimetres.

Tuber yield ha⁻¹ (tons)

Tuber yield plot⁻¹ was recorded by using a digital balance and covert to the yield ha⁻¹ by using formula and the average yield ha⁻¹ was noted.

$$X = \frac{\text{Total yield per plot}}{\text{Area of the plot}} \times 1000$$

X = Total yield ha⁻¹ in kilograms

Now convert in tons and divide the data by 1000 as below.

$$X = \frac{\text{Total yield per plot (kg)}}{1000}$$

X = Total yield ha⁻¹ in tons

The experimental research was conducted with a randomized complete block (RCB) Design with two factorial arrangements. All the significant data present among them were determined by the (LSD) test at a 5% level. Significant analysis of variance (ANOVA) was done by using the statistic 8.1 package (Keeling and Pavur, 2007).

Results and Discussion

Sprouting percentage (%)

Results showed that sprouting percentages were significantly affected by organic fertilizers and potato cultivars, while the interaction between organic fertilizers and potato cultivars was non-significant as shown in Table 2. From these results, it was determined that the maximum sprouting percentage (62.08 %) was recorded in cultivar Desiree while the minimum was found in cultivar Burna (51.08 %). The mean value of treatments shows that the maximum sprouting percentage was recorded in leaf mod (57.77 %), while the minimum sprouting percentage was recorded in the control treatment (51.88 %) Table 3. In all three cultivars, cultivar Desiree showed better performance in sprouting percentage which might be due to the genetic composition of this cultivar. As Mukhtar et al. (2010) found that among various potato cultivars, Desiree showed better genetic composition as compared to other cultivars.

Table 2: Means the square of various parameters of three potato cultivars under different fertilizers.

Source	Block (2)	Fertilizer (F) (3)	Cultivars (C) (2)	F x C (6)	Error (22)
Sprouting Percentage	23.028	113.213**	279.11**	1.296 ^{NS}	0.694
Days to Emergence	5.444	25.6574**	5.8611**	0.3796 ^{NS}	0.3232
Numbers of tubers plant ⁻¹	4.00	8.32407**	3.000**	0.18519 ^{NS}	0.39394
Tuber weight plants ⁻¹	0.0028	0.0093**	0.012**	0.0059 ^{NS}	0.59
Tuber diameter	0.2187	1.66763**	0.79910**	0.03143*	0.01026
Tuber yield ha ⁻¹	15.36	42.216**	40.27**	2.14	1.52

** = Significant at ($P \leq 0.01$), * = Significant at ($P \leq 0.05$), NS = Non-significant

Table 3: Sprouting percentage of potato cultivars as affected by organic fertilizers.

Treatment	Cultivars			Means
	Burna	Desiree	Cardinal	
Control	49.33	57.33	49	51.88 d
FYM	54.66	63.66	58.33	55.44 b
Leaf mold	56.33	66.33	55.00	57.77 a
Poultry manure	49.00	61.00	53.33	54.44 c
Means	51.08c	62.08a	53.41b	

LSD α 0.05 for organic fertilizer = 0.81

LSD α 0.05 for potato cultivars = 0.70

Mean which gets the identical letters not significantly different from one another at a 5 % level using the least significant difference (LSD) test.

Table 4: Day to emergence of potato cultivars as affected by organic fertilizers.

Treatment	Cultivars			Means
	Burna	Desiree	Cardinal	
Control	22.00	21.00	20.33	21.11 a
FYM	20.00	18.00	19.00	19.00 b
Leaf mold	18.00	17.00	17.33	17.44 c
Poultry manure	21.33	20.33	20.33	20.66 a
Means	20.33 a	19.08 b	19.24 b	

LSD α 0.05 for organic fertilizer = 0.55

LSD α 0.05 for potato cultivars = 0.70

Mean which gets the identical letters not significantly different from one another at a 5 % level using the least significant difference (LSD) test.

Almost all organic fertilizers showed better performance in sprouting than the control, it might be due to the high-water holding capacity which was provided by organic fertilizers and also provided the required temperature which was essential for sprouting. Leaf mold improves soil structure and provides a fantastic habitat for soil life and soil beneficial bacteria. Such findings were also confirmed by Jeff (2014) who experimented on the effect of compost on the yield of

potatoes and he also reported that organic fertilizers not only conserve moisture but also result in a temperature rise which enhances germination.

Days to emergence

Analysis of variance showed that days to emergence were significantly affected by organic fertilizers and potato cultivars, while the interaction between organic fertilizers and potato cultivars was non-significant as shown in Table 4. From these results, it was determined that Burna took a maximum number of days to emerge from the soil (20.33), while minimum days to germination were taken by cultivar Desiree (19.08). The mean value of treatments shows that a maximum number of days for germination was recorded in the control treatment (21.11), while the minimum was recorded in the leaf treatment (17.44). Among the three cultivars, cultivar Desiree showed better performance in germination which might be due to its genetic composition. Akhtar *et al.* (2010) also found in their experiment that among different cultivars, some cultivars showed better performance when grown in similar conditions.

Potato showed a good response to the application of Leaf mold, which might be due to leaf compost capability which increases soil porosity, water holding capacity and nutrient availability such as nitrogen, phosphorous, potash etc. Adeyeye *et al.* (2016) reported by applying leaf compost gives optimum temperature and moisture which helps in for emergence. Brundert *et al.* (1982) also explained that when plants are grown at optimum moisture levels they respond positively. Organic fertilizers are useful for plants due to their beneficial effect on the physical, chemical and biological characteristics of the soil, which in turns, influenced growth and increase plant production (Djaman *et al.*, 2021).

Number of tubers plant⁻¹

The experimental results revealed that the number of tubers plant⁻¹ was significantly affected by organic fertilizers and potato cultivars, while the interaction between organic fertilizers and potato cultivars was non-significant as shown in Table 5. From these results, it can be concluded that the maximum number of tuber plant⁻¹ was recorded in cultivar Desiree (4.58) which was statistically at par with cultivar Cardinal (4.08) while the minimum number of tubers was recorded in Burna (3.57). The mean value of treatments shows that a maximum number of tuber plant⁻¹ (5.5), was recorded in Leaf mold composted manure while the minimum number of tuber plant⁻¹ was recorded in the control treatment (2.99).

Table 5: Number of tubers plant⁻¹ of potato cultivars as affected by organic fertilizers.

Treatment	Cultivars			Means
	Burna	Desiree	Cardinal	
Control	2.66	3.33	3.0	2.99 d
FYM	3.66	5.0	4.66	4.44 b
Leaf mold	4.66	6.0	5.0	5.22 a
Poultry manure	3.33	4.0	3.66	3.66 c
Means	3.57 b	4.58 a	4.08 ab	

LSD α 0.05 for organic fertilizer = 0.6136

LSD α 0.05 for potato cultivars = 0.53

Mean which gets the identical letters not significantly different from one another at a 5 % level using the least significant difference (LSD) test.

Table 6: Tuber weight plant⁻¹ (kg) of potato cultivars as affected by organic fertilizers.

Treatment	Cultivars			Means
	Burna	Desiree	Cardinal	
Control	0.409	0.438	0.418	0.42 d
FYM	0.491	0.566	0.544	0.53 b
Leaf mold	0.615	0.703	0.659	0.65 a
Poultry manure	0.430	0.510	0.482	0.47 c
Means	0.488 c	0.556 a	0.526 b	

LSD α 0.05 for organic fertilizer = 0.03

LSD α 0.05 for potato cultivars = 0.02

Mean which gets the identical letters not significantly different from one another at a 5 % level using the least significant difference (LSD) test.

Since cultivar Desiree and cardinals have been sown in Parachinar for some time it is well adapted to the climatic conditions of this area and hence showed better performance. It might also be due to genetic composition. Gurabo (2009) experimented with the

effect of organic fertilizer on Sweet potato cultivars in South Africa and the result shows that the cultivar *Ipomoea batatas* L was best among all four commercial cultivars because of better genetic composition. All organic fertilizers affected the number of tuber plant⁻¹ positively than the control, this might be because organic fertilizers helped in water holding capacity, and soil aeration and increased the beneficial soil micro-organisms which help in providing nutrients to the plant which has a better effect on plant height, several leaves and number of branches due to which more carbohydrates are prepared which helps in increasing the number of tubers. Lutz (1981) also found that compost helped in the conservation of heavy metals and recycling processes of nutrients and elements. Leaf mold is a great soil amendment. It is essentially a soil conditioner that increases the water retention of soils. Nath and Sharma (1982) also reported finds out that when citrus seedlings were grown in paddy husks, sawdust, poultry manure and Leaf mold, it improved the water-holding capacity of soil and resulted in better performance.

Tuber weight plant⁻¹ (kg)

Substantial differences were found between organic fertilizers and potato cultivars and non-significant interactions were found between organic fertilizers and potato cultivars for tuber weight plant⁻¹ (Table 6). Maximum tuber weight plant⁻¹ (0.556 kg) was recorded in cultivar Desiree while the minimum was recorded in Burna (0.448 kg). The mean value of treatments shows that the maximum tuber weight plant⁻¹ was recorded in the Leaf mold (0.659 kg), while the minimum tuber weight plant⁻¹ was recorded in the control treatment (0.422 kg). The highest tuber weight was recorded with Desiree among all the three varieties, which was due to higher plant, maximum number of branches and maximum number of tubers.

Tuber weight increases because potatoes showed the best response to compost application and it increases soil porosity, water holding capacity and nutrient availability to the plants. Sharif et al. (2003) also applied organic manure and recorded that the highest tuber weight was achieved with the application of farmyard manure and Leaf mold, while the lowest tuber weight was recorded in control. Garner et al. (1966) also experimented on a comparison of farmyard manure, sewage sludge and other organic manure on potatoes and cereal crops at Rothamsted, and found that organic fertilizers affected the cereal and

the potatoes yield and the plots which received leaf compost have larger size of potato tubers and having the more number of leaves.

The plots which received leaf mold fertilizer have a large size of potatoes because of the greater number of branches and leaves which means that organic fertilizer helped increase the number of leaves which affected the tuber size and weight. These results are in contrast with Singh and Kushwah (2006) who applied organic and inorganic fertilizer and their combination on potatoes for their growth and yields and concluded that farmyard manure showed better growth and yields as compared to compost.

Table 7: Tuber diameter (cm) of potato cultivars as affected by organic fertilizers.

Treatment	Cultivars			Means
	Burna	Desiree	Cardinal	
Control	2.09	2.47	2.26	2.27 d
FYM	2.50	2.00	2.71	2.40 b
Leaf mold	2.89	3.70	3.20	3.26 a
Poultry manure	2.32	2.70	2.55	2.52 c
Means	2.45 c	2.71 a	2.68 b	

LSD α 0.05 for organic fertilizer = 0.099

LSD α 0.05 for potato cultivars = 0.085

LSD α 0.05 for the interaction of FxC = 0.17

Mean which gets the identical letters not significantly different from one another at a 5 % level using the least significant difference (LSD) test.

Tuber diameter plant⁻¹ (cm)

Means squares revealed that the tuber diameter plant⁻¹ was significantly affected by organic fertilizers and potato cultivars, while the interaction between organic fertilizers and potato cultivars was also significant (Table 7). The results showed the maximum tuber diameter plant⁻¹ (2.71 cm) in Desiree while the minimum was recorded in Burna (2.45 cm). The mean value of the treatments showed maximum tuber diameter plant⁻¹ during Leaf mold application (3.26 cm), while the minimum tuber diameter plant⁻¹ was recorded in the control treatment (2.27 cm). In the interactive effect, the maximum tuber diameter was recorded in Leaf mold composted fertilizer (3.70 cm) while the minimum tuber diameter (2.00 cm) was recorded in farmyard manure; both the maximum and minimum potato tuber diameter was recorded in cultivar Desiree (Table 6). Cultivar Desiree performed well in almost all the growth parameters and supplied maximum nutrients that increased cell division and

the number of cells due to which the tuber diameter increased. It conforms with Gelaye (2023) who reported that soil nutrients can increase the assimilation rates and hence increase the photosynthetic rates which increase cell division and promote increased tuber size.

The organic fertilizers affected the diameter of potatoes because of nutrients availability in organic fertilizers as Warma (2001) noted that long-term application of compost to different vegetables positively affected leaf area, size of tuber, the number of tubers, stems, leaves, number of tubers, pods, growth of plants etc as compared to the control treatments. Organic manure also helps against the nematode and helps in increasing the total yield Kinopriski *et al.* (2009) conducted an experiment on the effect of compost and Manure on soil amendment on nematode and yield of potatoes and barley and continued this experiment for seven years from 2003 to 2009. In this experiment, he applied the compost and manure at the rate of 10 tonnes per hectare, in which both potatoes and barley showed good results in each parameter and resistance against the nematodes.

Table 8: Tuber yield (tons) ha⁻¹ of potato cultivars as affected by organic fertilizers.

Treatment	Cultivars			Means
	Burna	Desiree	Cardinal	
Control	18.51	21.16	21.16	20.27 d
FYM	22.48	26.89	23.80	24.39 b
Leaf mold	22.92	28.22	25.57	25.57 a
Poultry manure	21.16	23.80	22.48	22.48 c
Means	21.26 c	25.01 a	23.25 b	

LSD α 0.05 for organic fertilizer = 0.099

LSD α 0.05 for potato cultivars = 0.085

LSD α 0.05 for the interaction of FxC = 0.17

Mean which gets the identical letters not significantly different from one another at a 5 % level using the least significant difference (LSD) test.

Total yield ha⁻¹ (tons)

The experimental results show that total tuber yield ha⁻¹ was significantly affected by organic fertilizers and potato cultivars, while the interaction between organic fertilizers and potato cultivars was non-significant (Table 8). From these results, it was determined that the maximum tuber yield ha⁻¹ (25.01 tons) was recorded in cultivar Desiree while the minimum was recorded in Burna (21.26 tons). The mean value of treatments shows that the maximum tuber yield

ha⁻¹ was recorded in Leaf mold fertilizer (25.57 tons), while the minimum tuber yield ha⁻¹ was recorded in the control treatment (20.27 tons).

The highest tuber yield ha⁻¹ was recorded in cultivar Desiree among all the three varieties, as it attained maximum height, maximum number of branches, leaves and maximum tuber weight and diameter and hence resulted in maximum tuber yield ha⁻¹. Ewulo *et al.* (2008) reported best result of potato yield on poultry manure with 10 tons ha⁻¹. In some cases, Leaf mold may indeed contribute to higher yields due to its nutrient content and its ability to improve soil health over time (Gelaye, 2023). The plots which received the Leaf mold fertilizer had a large size of potatoes and had high yields because more branches and leaves were recorded in those plots which means that organic fertilizer helps in increasing the number of leaves which affects the tuber size and weight these results were confirmed by Julia (2014) who conducted an experiment on the effect of compost, chicken manure and inorganic fertilizer on potatoes quality and yield and observed good result in all parameter, where the compost was applied. Jeff (2014) also confirmed his experiment that leaf compost fertilizer helped in the conservation of moisture and supply of nutrients which resulted in maximum yield.

Conclusions and Recommendations

Based on the findings of this study, it was concluded that Leaf mold fertilizer showed better results therefore, Leaf mold fertilizer at the rate of 10 tons ha⁻¹ is recommended for potato farming. Cultivar Desiree performed better in sprouting percentage (%), plant height, number of leaves plant⁻¹, number of branches stem⁻¹, number of tuber plant⁻¹, tuber weight plant⁻¹, tuber diameter, tuber yield ha⁻¹ among all the selective cultivars hence recommended to promote the adoption of organic fertilizers to enhance yield and quality for the agro-climatic conditions of Parachinar. Furthermore, this study recommended the focus on optimizing application rates, timing for sustainable production and exploring economic benefits for the local farmers.

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nificantly advanced our understanding of the subject matter, enriching the field with their expertise.

Novelty Statement

This study revolutionizing the promotion and adaptation of organic fertilizers in potato cultivation at Parachinar, Unleashing the potential of organic fertilizers for superior yields the application of Leaf Mold.

Author's Contribution

Iqrar Hussain: Principal author, conducted research, analysis and wrote this MS.

Ibrar Hussain: Helped in research trials.

Fazal-i-Wahid: Supervised the research study.

Ghani Gul: Helped in research methodology and analysis.

Waseem Ullah Shah: Format setting.

Muhammad Numan: Helped in relevant literature.

Muhammad Anas: Helped in submission and editing.

Conflict of interest

The authors have declared no conflict of interest.

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