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Effect of different doses of NPK fertilizers on seed yield of okra (*Abelmoschus esculentus* (L) Moench)

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Abstract

Okra is one of the most important summer vegetables of Pakistan. It is mainly grown from seeds which are very poor in quality. They lose their viability very quickly so that it becomes essential to produce fresh good quality seeds every year to get higher yield of crop. Among the various agronomic practices influencing seed production of okra, the nutrition is reported to exert a great influence on yield and seed quality of okra. There are various ways for improving yield and seed production of okra but the best way is to provide appropriate amount of fertilizers. Therefore, a field study was conducted at Vegetable Seed Production Farm Quetta to examine the effect of different doses of NPK fertilizers on seed yield of okra. The experiment was Randomized Complete Block Design. There were five treatments and four replications. Data showed that yield of green pods per plant increased with the increase of fertilizers while data regarding number of seed/pod showed the significant difference among all means. M_5 occupied the highest while M_1 lowest position. Data regarding seed yield per plant showed highly significant results from table of analysis of variance. Mean values indicated that M_5 and M_3 stood at per likewise, M_4 and M_2 behaved same. M_5 got position at top while M_1 stood at the bottom in which, no dose of fertilizer was used. Furthermore, there had no effect of NPK fertilizers with different levels to increase the weight at 1000-seeds.

Keywords: NPK fertilizers, effect, seed yield, okra, Quetta

Introduction

Vegetable crops are very important due to their higher yield potential, higher return and high nutritional value and suitability for small land holding farmers. Vegetables provide proteins, minerals and vitamins required for human nutrition (Khokhar, 2014). Okra (*Abelmoscus esculentus* (L) Moench) is one of the important summer vegetables grown throughout the tropical world including Pakistan (Amjad *et al*., 2002).

It belongs to the family Malvaceae and is semi-cross pollinated in nature. In Pakistan, it is valued as a source of good income for the growers. The total area in growing season 2008-09 under okra cultivation in Pakistan was 15.081 thousand hectares with total production of 114.657 thousand tons (MINFA, 2009 and Sajid *et al*., 2012) while in Balochistan, the cultivated area is 2737 hectares and production 6822 tons in 2007-08 (Government of Balochistan, 2008). In Pakistan, Balochistan province contributes 16% of the total production of okra (Khokhar, 2014).

Okra as vegetable is choice of every rich and poor alike and it is cultivated almost round the year. Generally okra is cultivated as kharif crop, but due to varied climates in different parts of the country, it is available in the market almost all months of the year (Solangi *et al*., 2015). In Pakistan, okra is usually known as bhindi. It is primarily grown for its immature pods that can be consumed as a fried or boiled vegetable or may be added to salads, soups and stews (Kashif *et al*., 2008 and Baloch *et al*., 2013). It is a rich source of valuable nutrients, like protein, carbohydrate, fat, ash, vitamins (A, B, and vitamin C) and minerals especially iodine (Draper, 2009 and Afzal *et al*., 2015). It also have soluble and insoluble fibers, which helps to lower serum cholesterol, risk of heart diseases, keeps the intestinal tract healthy and decreases the chances of colorectal cancer (Broek *et al*., 2007 and Afzal *et al*., 2015).

Despite the nutritional value of okra, the average yield per unit area is low as compared to other countries probably due to low nutrients or climatic conditions (Naheed *et al*., 2013). There are various ways for improving yield and seed production of Okra but the best way is to provide appropriate amount of fertilizers and to select high yielding cultivars. Fertilizer is a material that is added to the soil to supply one or more elements required for plant growth and development (Masarirambi *et al*., 2012 and Ginindza *et al*., 2015). Chemical fertilizers are inorganic fertilizers which are formulated in appropriate concentrations and combinations which supply three main nutrients: nitrogen, phosphorus and potassium (N.P.K) for various crops and growing conditions. Nitrogen (N) promotes leaf growth and forms proteins and chlorophyll. Phosphorus (P) contributes to root, flower and fruit development. Potassium (K) contributes to stem and root growth and the synthesis of proteins ((Jayaweera & Mikkelsen, 1991 and Ginindza *et al*., 2015).

Okra is mainly grown from seeds which are very poor in quality. They lose their viability very quickly so that it becomes essential to produce fresh good quality seeds every year to get higher yield of crop. Among the various agronomic practices influencing seed production of okra, the nutrition is reported to exert a great influence on yield and seed quality of okra. Keeping these in view, an experiment was conducted at the vegetable seed production farm Quetta, to see the effect of varying levels of Nitrogen, Phosphorus and Potassium on seed yield of okra.

Materials and Methods

This research study was carried out at the Vegetable Seed Production Farm Quetta and Materials for this study were consisted of Okra cultivar's cv. "Pusa Green" and the fertilizers used for the crop were Nitrogenous, Phosphorus and Potassium. These were combined in different proportions. The experiment was Randomized Complete Block Design (RCBD). There were five treatments and four replications. Total experimental units were 20 (including control in which there was no fertilizer application). Detailed accounts of the various combinations are as follows:

Table 1: Lay out plan design, treatments:

R1	**T0** **Control**	**T3** 100kg N/hac 100kg P/hac	**T1** 60kg N/hac 60kg P/hac	**T2** 100kg N/hac 80kg P/hac 60kg K/hac	**T4** 140kg N/hac 100kg P/hac 60kg K/hac
R2	**T4** 140kg N/hac 100kg P/hac 60kg K/hac	**T2** 100kg N/hac 80kg P/hac 60kg K/hac	**T1** 60kg N/hac 60kg P/hac	**T0** **Control**	**T3** 100kg N/hac 100kg P/hac
R3	**T2** 100kg N/hac 80kg P/hac 60kg K/hac	**T1** 60kg N/hac 60kg P/hac	**T4** 140kg N/hac 100kg P/hac 60kg K/hac	**T3** 100kg N/hac 100kg P/hac	**T0** **Control**
R4	**T4** 140kg N/hac 100kg P/hac 60kg K/hac	**T3** 100kg N/hac 100kg P/hac	**T1** 60kg N/hac 60kg P/hac	**T0** **Control**	**T2** 100kg N/hac 80kg P/hac 60kg K/hac

Half of nitrogen, full doses of phosphorus and potassium were applied at the time of bed preparation. The remaining half nitrogen was applied 30 days after sowing of okra crop.

Data recorded

Number of green pod per plant

Data for this parameter were recorded after one week of first flowering by counting green pods per plant for all the treatments, later on mean values were calculated.

Yield of green pods per plant (gm)

The data were recorded from already randomly marked plants. Green pods were picked from each treatment after every week of flowering. There were total 7 pickings and their weights were recorded each time. Mean values of these observations were calculated and analyzed.

Yield of green pods per hectare (kg)

Since the yield per hectare was calculated from yield per plant and plot size, it has identical situation with each other. Mean values were calculated and analyzed.

Number of seeds per pod

The observations were recorded by counting number of seeds per pod and these pods were picked from one plant. The procedure was repeated for those ten plants per block and in every block for different treatments. Mean values from those observations were calculated.

Length of mature pods (cm)

When pods of plant were mature and picked then the data were taken by measuring length of all pods individually per plant with the help of measuring tape. This procedure was done with all marked ten plants per block and in every block for different treatments. Mean values were calculated from those observations.

Seed yield per plant (gm)

Data were taken from marked plants. First observations were taken 25 days of first flowering by hand picking of mature pods from every plant. Later on those pods per plant were collected in different marked envelopes. The procedure was done for every marked plant in experimental field. Those envelopes were taken to the Laboratory for getting weight of seeds in every envelope in which total seeds obtained per plant were present. The overall procedure was repeated for 4-5 times after every 20 days. Mean values were taken from those observations.

Weight of 1000-seeds (gm)

Different mature pods were harvested from different plants in a block. Seeds of these plants were collected and counted till 1000 numbers. The weight of these 1000-seeds was measured on Electrical Balance. The procedure was done for every block at the same time in the experimental area. Differences were noted for different treatments in weight of 1000-seeds. Mean Values were calculated from those observations.

Seed yield per hectare (kg)

Since the seed yield per hectare was calculated from seed yield per plant and per plot size as given before, it has identical situation with each other. Mean values were calculated and analyzed.

Statistical analysis

Data for experimental study were subjected to statistical analysis and given in table termed as analysis of variance (Steel & Torrie, 1980), which would indicate significance level on the treatment differences. Mean values for the treatments.

Results and Discussion

Number of green pod per plant

Data in concerning number of pods per plant are presented in **Table 2** as analysis of variance after having subjected to statistical analysis. Statistical analysis showed highly significant results for fertilizer treatments. Mean values for fertilizer treatments were subjected to Duncan's Multiple Range Test (DMRT) and arranged in a descending order. These are given below indicating both original and ranked order for comparison of study.

Table 2: Mean for number of green pods/plant

Original Order	Ranked Order
Mean 1= 11.5 E	Mean 5= 15.00 A
Mean 2= 13.00 D	Mean 3= 14.00 B
Mean 3= 14.00 B	Mean 4= 13.5 C
Mean 4= 13.5 C	Mean 2= 13.00 D
Mean 5= 15.00 A	Mean 1= 11.5 E

Analysis of variance expressed highly significant results for fertilizers treatment for this factor of study. Mean values indicate that M_1 and M_3 stood at par. M_3 over M_4, M_4 over M_2 and M_2 over M_1 had significant difference. Hence these means followed a sequence of M_5, M_3, M_4, M_2 and M_1 in a descending order. With the increase of fertilizers, numbers of pods/plant were increased. Randhawa & Punnum (1970) and Sharestha (1983) also reported similar results in this respect.

Yield of green pods per plant (gm)

Data in pertaining to this factor of study were subjected to statistical analysis and the results obtained are presented in **Table 3** as analysis of variance. The table stated highly significant result for fertilizer at one percent level. Mean values for various treatments indicating significant results were arranged in a descending order according to DMRT. These are given below for comparative studies.

Table 3: Mean for yield of green pods/plant

Original Order	Ranked Order
Mean 1= 78.013 E	Mean 5= 98.96 A
Mean 2= 90.27 D	Mean 3= 95.39 B
Mean 3= 95.39 B	Mean 4= 90.34 C
Mean 4= 90.34 C	Mean 2= 90.27 D
Mean 5= 98.96 A	Mean 1= 78.013 E

It was observed from above statement that M_5 achieved superiority over others. M_1 was observed at the bottom. M_4 and M_2 had non-significant difference only whereas; M_3 and M_1 had significant difference and so on. The mean followed a sequence of M_5, M_3, M_4, M_2, and M_1 in a descending order respectively.

Data regarding this factor indicated highly significant results for fertilizers at 1 percent level as revealed by analysis of variance. Mean values for fertilizer doses indicated that the 5 treatments differed significantly from each other. It was observed greater the fertilizers better the performance of plant. Yield of green pods per plant increased with the increase of fertilizers. NPK fertilizers could be given as example. It is an established fact that N is usually considered better for vegetative growth. Higher dose are then expected to present better results.

Similar results were observed by Saimbhi & Padda (1970), Mani & Randhawa (1980) and Lenka *at al.* (1989).

Yield of green pods per hectare (kg)

Observations recorded for this factor of study were subjected to statistical analysis and results obtained are presented in **Table 4** as analysis of variance. This table sponsored highly significant results for fertilizer treatments. Mean values for the fertilizer treatments indicating high significant results were subjected to DMRT and results obtained are presented below for comparative studies.

Table 4: Mean for yield of green pods/hectare (kg)

Original Order	Ranked Order
Mean 1= 5092.5 E	Mean 5= 6837.5 A
Mean 2= 6048.8 D	Mean 3= 6455.0 B
Mean 3= 6455.0 B	Mean 4= 6108.5 C
Mean 4= 6108.5 C	Mean 2= 6048.8 D
Mean 5= 6837.5 A	Mean 1= 5092.5 E

The above statement indicated significant superiority of M_5 over rest of the treatments. M_5 and M_3 had significant difference between them. These means followed a sequence of M_5, M_3, M_4, M_2, and M_1 descending order respectively.

Analysis of variance table regarding this factor of study indicated highly significant results for fertilizer application at 1 percent level. From the test it is noted that the fertilizer application presented an ideal situation, higher doses of fertilizer perform better production of green pods per hectare. It was calculated on basis of yield per plant and per plot. It is established fact that N is usually considered better for vegetative growth. K is for quality of yield. These all components affected positively by increase their concentration. M_5 achieved top position and M_1 got lowest position.

Similar results were observed by Saimbhi & Padda (1970), Mani & Randhawa (1980), and Lenka *at al.* (1989).

Number of seeds per pod

Data recorded for this factor of study were subjected to statistical analysis and results obtained are presented in **Table 5** as analysis of variance. This showed highly significant results for fertilizer treatments. Mean values for the fertilizer treatments indicating significant results were subjected to DMRT obtained are presented below for comparative studies.

Table 5: Mean for number of seeds/pod

Original Order	Ranked Order
Mean 1= 29.00 E	Mean 5= 39.75 A
Mean 2= 32.00 D	Mean 3= 38.25 B
Mean 3= 38.25 B	Mean 4= 34.50 C
Mean 4= 34.50 C	Mean 2= 32.00 D
Mean 5= 39.75 A	Mean 1= 29.00 E

It was observed from above statement that the various means followed the sequence of M_5, M_3, M_4, M_2 and M_1 in descending order respectively. These showed significant difference among all means. M_5 occupied the highest and M_1 lowest while M_4 was in middle position. This showed the result that with the improvement of amount of fertilizers including NPK, numbers of seed per pod are increased with its good shape.

Length of mature pods (cm)

Observations recorded for this factor of study were subjected to statistical analysis and the results obtained are presented in **Table 6** as analysis of variance. This Table showed high significant results for different fertilizer treatments. Mean values for the various treatments indicating significant results were arranged in a descending order according to DMRT. These are given below for comparative studies.

Table 6: Mean for mature pods (cm)

Original Order	Ranked Order
Mean 1= 11.35 E	Mean 5= 13.90 A
Mean 2= 11.92 D	Mean 3= 13.25 B
Mean 3= 13.25 B	Mean 4= 12.65 C
Mean 4= 12.65 C	Mean 2= 11.92 D
Mean 5= 13.90 A	Mean 1= 11.35 E

Above statement expressed highly significant results for fertilizers treatments for this factor of study. M_5 got the top position and M_1 achieved at bottom. One factor, however, seemed clear that highest dose proved effective than lowest. M_5 is superior over M_3 and M_3 over M_4 and so on. It is noted that higher the dose of fertilizer more length of mature pods was achieved.

Seed yield per plant (gm)

Data pertaining to this factor of study were subjected to statistical analysis and the results obtained are presented in **Table 7** as analysis of variance. This table showed highly significant results for the various treatments. Mean values are given below simply for the interest of reader. These were arranged in a descending order for DMRT. Mean values for fertilizer are presented below for comparative studies.

Table 7: Mean for seed yield/plant (gm)

Original Order	Ranked Order
Mean 1= 25.5 E	Mean 5= 33.25 A
Mean 2= 27.0 D	Mean 3= 30.5 B
Mean 3= 30.5 B	Mean 4= 27.0 C
Mean 4= 27.0 C	Mean 2= 27.0 C
Mean 5= 33.25 A	Mean 1= 25.5 D

Data regarding this factor of study revealed highly significant results from table of analysis of variance. Mean values indicated that M_5 and M_3 stood at per likewise M_4 and M_2 behaved same. M_5 got position at top and M_1 achieved at bottom. M_5 was superior over M_3 and M_3 over M_4 and so on. These means followed sequence of M_5, M_3, M_4, M_2 and M_1 is a descending order. M_1 stood at the bottom in which, no dose fertilizer was used. It was cleared that M_5 (N=140 kg/hac, P=100 kg/hac and K = 60 kg/hac) was found superior to increase seed yield per plant. It was presumed that fertilizer elements are responsible to increase seed grains weight.

Similar results were observed by Mishra & Pandey (1987), Rastogi *et al.* (1987) and Lenka *et al.* (1989).

Weight of 1000-seeds (gm)

The observations recorded for this factor of study were subjected to statistical analysis and the results obtained are presented in **Table 8** as analysis of variance. On the data having significant results, DMRT is applied.

Table 8: Mean for weight of 1000-seeds (gm)

Original Order	Ranked Order
Mean 1= 65	Mean 5= 65
Mean 2= 65	Mean 3= 65
Mean 3= 65	Mean 4= 65
Mean 4= 65	Mean 2= 65
Mean 5= 65	Mean 1= 65

Information collected about analysis of variance of this factor of study revealed results significant for all treatments of fertilizer. There was application of DMRT on such data. It was concluded that there had no effect of NPK fertilizers with different levels to increase the weight at 1000-seeds.

For this factor of study results of Rastogi *et al.* (1987) favored but Mishra & Pandey (1987) gave opposite results.

Seed yield per hectare (kg)

Data concerning seed yield per hectare are given in **Table 9** as analysis of variance after have been subjected to statistical analysis. This analysis concluded highly significant results for different fertilizer treatments. Mean values for fertilizer treatments were subjected to DMRT and arranged in a descending order. These are given below indicating both original and ranked order for comparative studies.

Table 9: Mean for seed yield/hectare (kg)

Original Order	Ranked Order
Mean 1= 1664.0 E	Mean 5= 2297.3 A
Mean 2= 1778.5 D	Mean 3= 2080.8 B
Mean 3= 2080.8 B	Mean 4= 1823.5 C
Mean 4= 1823.5 C	Mean 2= 1778.5 D
Mean 5= 2297.3 A	Mean 1= 1664.0 E

Data regarding this factor indicated highly significant results for fertilizer at 1 percent level as revealed by the analysis of variance. Mean values for fertilizer doses indicated that treatments differed significantly from each other. Present studies have confirmed these findings, indicating by significant superiority as highest doses over the lowest one. The intermediate dose significantly indicated statistical behavior with both in the highest and lowest doses simultaneously although exhibiting clear significant superiority of M_5 over M_3 and M_4 and so on. These means followed a sequence of M_5, M_3, M_4, M_2 and M_1 in descending order. M_5 got highest position and M_1 achieved lowest position. Hence in M_5 (N=140 Kg/hac, P=100 kg/hac and k=60 kg/hac) remained best combination of fertilizers to increase seed yield per hectare. By including NPK fertilizers, seed yield per hectare was increased to notable level. Fertilizers had positive effect on seed yield per hectare to particular level and combinations.

Similar results were observed by Mishra & Pandey (1987), Rastogi *et al.* (1987) and Lenka *et al.* (1989).

Conclusion

From the results of the study it is concluded that green pods gave highly significant results for fertilizer treatments. With the increase of fertilizers, numbers of pods were increased. Data regarding yield of green pod per hectare showed highly significant results for higher dose of fertilizers. Yield per hectare increased with increase of dose of fertilizer like M_5 (N=140 kg/hac, P=100 kg/hac, and K=60 kg/hac) whereas, with the increase of fertilizer doses, number of seed/pod were increased with its good shape. It is further concluded that the presence of NPK fertilizers in raised quantity, increased length of mature pod while seed yield per plant depicted highly significant results for fertilizer. Mean values for fertilizer declared significant results for fertilizer declared significant superiority of M_5 (N=140 kg/hac, P=100 kg/hac, and 60 kg/hac). M_1 stood at the bottom in which, no dose fertilizer was used. By including NPK fertilizers, seed yield per hectare was increased to notable level while there had no effect of NPK fertilizers with different levels to increase the weight at 1000-seeds.

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APPENDICES

Table 2a: Analysis of variance for number of green pods/plant

S.O.V	D.F	S.S	M.S	F. CAL	PROB.
Rep	3	3.6000	1.2	3.27	0.1061
Fertilizer	4	26.8000	6.7	18.27	0.0000
Error	12	4.4000	0.3666		
Total	19	34.8000			

** = Highly Significant

Table 3a: Analysis of variance for yield of green pods/plant

S.O.V	D.F	S.S	M.S	F. CAL	PROB.
Rep	3	15.74	5.247	2.32	0.0955
Fertilizer	4	1006.16	251.54	111.25	0.0000
Error	12	27.14	2.2610		
Total	19	1049.04			

** = Highly Significant

Table 4a: Analysis of variance for yield of green pods/hectare (kg)

S.O.V	D.F	S.S	M.S	F. CAL	PROB.
Rep	3	137345	45782	3.72	0.1228
Fertilizer	4	6749317	1687329	137.10	0.0000
Error	12	147684	12307		
Total	19	7034347			

** = Highly Significant

Table 5a: Analysis of variance for number of seeds/pod

S.O.V	D.F	S.S	M.S	F. CAL	PROB.
Rep	3	13.400	4.4667	2.13	0.2288
Fertilizer	4	311.700	77.925	37.25	0.0000
Error	12	25.100	2.0917		
Total	19	350.2			

** = Highly Significant

Table 6a: Analysis of variance for length of mature pod (cm)

S.O.V	D.F	S.S	M.S	F. CAL	PROB.
Rep	3	0.2055	0.0685	1.44	0.0670
Fertilizer	4	16.5280	4.132	86.68	0.0000
Error	12	0.5720	0.04767		
Total	19	17.3055			

** = Highly Significant

Table 7a: Analysis of variance for seed yield/plant (gm)

S.O.V	D.F	S.S	M.S	F. CAL	PROB.
Rep	3	2.550	0.85	1	0.0319
Fertilizer	4	159.800	39.95	47.00	0.0000
Error	12	10.200	0.85		
Total	19	172.550			

** = Highly Significant

Table 8a: Analysis of variance for weight of 1000-seeds (gm)

S.O.V	D.F	S.S	M.S	F. CAL	PROB.
Rep	3	9.92728	3.3091	5.5951	
Fertilizer	4	8.25028	2.063	3.49	0.0000
Error	12	7.10160	0.591		
Total	19	25.27916			

* = Significant

Table 9a: Analysis of variance for seed yield/hectare (kg)

S.O.V	D.F	S.S	M.S	F. CAL	PROB.
Rep	3	7093	2364.33	0.56	0.0147
Fertilizer	4	1050566	262641.5	62.38	0.0000
Error	12	50524	4210.3		
Total	19	1108183			

** = Highly Significant

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