EVALUATION OF VARIOUS METHODS OF FERTILIZER APPLICATION IN POTATO (*Solanum tuberosum* L.)

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ABSTRACT

The experiment on "Evaluation of various methods of fertilizer application in potato (*Solanum tuberosum* L.)" variety Desiree, was conducted at Agricultural Research Station (North) Mingora, Swat, during autumn 1998. A Randomized Complete Block (RCB) Design with three replication and 21 treatments were used. Plant to plant and Row-to-Row distance of 25 and 75 cm were kept in all treatment, making plot size of 2.25×3 meter per treatment. Three different methods of fertilizer application (Broadcasting, Banding and Placement) with seven levels of Nitrogen (0, 50, 100, 150, 200, 250 and 300 kg ha^{-1}) were applied. Various methods of fertilizer application showed highly significantly variations for number of tubers $plot^{-1}$, percent ground cover or growth rate, tuber size, and tuber yield $hectare^{-1}$ (tons). Analysis of variance for interaction showed highly significant differences ($P<0.01$) for all the characters studied. The same trends of high significance were also found among different levels of Nitrogen. It was found that maximum number of tubers (170.33) $plot^{-1}$, tuber size (63.33 mm) maximum percent ground cover (59.33 %), and tuber yield $hectare^{-1}$ (19.28 tons) was recorded in plots, which received fertilizer through banding. In case of interaction, best results were recorded in plots where nitrogen at the rate of 150 kg $hectare^{-1}$ was applied through banding. The result lead to the conclusion that "Banding" is the most efficient and economical method of fertilizer application in potato and 150 kg N ha^{-1} is the promising level of nitrogen for excellent results in potato crop under the agroclimatic conditions of Mingora, Swat.

Keywords: Fertilizer Application, Potato, *Solanum tuberosum* L.

INTRODUCTION

Potato (*Solanum tubersum* L.) belongs to the family solanaceae and ranked 5th as food and industrial crop. It produces 5524 kg proteins per hectare as compared to wheat and paddy, which produce 247 kg ha^{-1}. In countries where potato is used as staple food, are exporting food commodities, while where potato use as vegetable crop are under crisis.

Potato is native to South America and later introduced in Spain during 1570. In England its cultivation started during 1588-93 (Hawkes 1967). In Indo-pakistan commercial cultivation of potato started in 1900 with the arrival of British Government. At the time of independence potato was grown on an area of 3000 ha. During past two decades, it gained economic importance in the country including Northern Area's. Potato average yield ranged from 13.50 to 16.40 t ha^{-1} during 1995 to 2002, respectively (Anonymous, 2003).

Potatoes are grown under a wide range of altitudes (from sea level to over 4000 meter elevation), latitudes (from equator to more than 40 north south) and climatic conditions than any other major food crop. The diversity of agro-climatic zones in which potatoes are grown practically defies classification. However, three ideal types of production zones can be identify as 1. highland zones, 2. Lowland tropical and subtropical zones and 3. Temperature zones (Harris, 1992). In Northern Areas potato is grown on an area of 6483 ha with the production of 72660 t (Anonymous, 2001).

Practically cultivated soils in Pakistan are deficient in Nitrogen and occasionally need replenishment of phosphorus, potassium and zinc. Most workers agreed that nitrogen is need in large quantity in mineral soils. Optimum application of nitrogen fertilizer in appropriate methods is a key of success in increasing potato yield. Determining the need for supplementary fertilizer is often very difficult. This difficulty is mostly due to economic reasons like cost of fertilizer inputs. So this difficulty can be removed by using efficient fertilizer application methods.

The objective of the present research study is an effort to evaluate various methods of fertilizer application with respect to different level of Nitrogen in potato variety Desiree.

MATERIALS AND METHODS

The present study was conducted at Agricultural Research Station (North) Mingora, Swat, during autumn 1998 to evaluate various methods of fertilizer application in combination with different

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dozes of nitrogen fertilizer in potato, variety Desiree.

The following practices were carried out before sowing.
The experimental area was properly leveled and pulverized to break the clods and then well drained ridges 75 cm apart were made. Soil analysis was carried out before fertilizer application. Soil samples up to 25 cm depth were taken randomly from different part of the field and then analyzed in the laboratory. Laboratory results indicated that the soil was silty clay loam with nitrogen (0.075 %), $CaCO_3$ (4.92 %), Organic Matter (1.5 %) P_2O_5 (10.8 ppm), K_2O (104.6 ppm) and pH with 7.1. A Randomized Complete Block Design with three replications and two factors (methods of fertilizer application and level of nitrogen) were applied. Three methods of fertilizer application Broadcasting, Banding and Placement and seven level of nitrogen 50, 100, 150, 200, 250 and 300 kg ha^{-1} with one control treatments were used.

Healthy and diseased free seeds of potato variety Desiree were planted 15 cm deep with plot size of 2.25×3 m per treatment was maintained used. Recommended dose of phosphorous and potassium fertilizer (100:50 kg ha^{-1}) were constantly applied to all treatments at the time of land preparation with two split doses; before planting and at earthingup after 35 days after planting according to various levels and methods of the experimental plan. Regular weeding and hoeing were carried out. First irrigation was done after two days of planting and then according to the crop requirement and was stopped prior to 15 days of harvesting. Insecticide Methyl parathion @ 15cc/10L of water was sprayed and once repeated at 10 days interval. For late blight and leaf spots Trimultax @ 30 gm/10L of water was sprayed and repeated twice at 10 days interval.

Data were recorded on the following parameters.

Number Of Tubers Plot^{-1}

The data were recorded by counting the tuber produced by each plot separately.

Tuber Size

To measure tuber size $plot^{-1}$ five tubers of different sizes from each plot were selected randomly. Their diameters were measured and average size of tubers $plot^{-1}$ was calculated.

Growth Rate

The percent ground cover of growth rate was calculated on six different dates with 15 days interval after germination. A wooden frame with 100 divisions (holes) on 1 meter × 75 cm area was used to measure percent ground cover. For data collection, the frame was fixed above the plants between two rows and the area covered with green leaves within the holes of the frame was considered percent plant canopy or ground cover.

Tuber Yield ha^{-1} (tonnes)

Yield ha^{-1} was calculated with the help of the formula;

$$\text{Yield } ha^{-1} \text{ in tonne} = \frac{\text{Yield } plot^{-1} \times 10{,}000\ m^2}{\text{Area of plot} \times 1000}$$

Data were analyzed by using Mstat-C Statistical package following the method proposed by Gomez and Gomez (1983). Since main effect of various fertilizer application method and methods × nitrogen levels interaction were significant for important yield traits, least significant difference (LSD) test was used for mean separation.

RESULTS AND DISUSSION

Number of Tubers Plot^{-1}

Analysis of variance for number of tubers $plot^{-1}$ showed highly significant differences among various methods of fertilizer application, levels of nitrogen and also for interaction between them. This declared differences in response to methods and amount of fertilizer application in potato (Table I).

Number of tubers $plot^{-1}$ ranged from 81.00 to 159.00, 82.33 to 170.33 and 81.33 to 151.67 for broadcasting, banding and placement methods, respectively (Table I). Maximum number of tubers $plot^{-1}$ were recorded for banding (170.33) and broadcasting (159.00), when nitrogen @ 300 kg ha^{-1} applied in potato. By using the same methods (broadcasting and banding) minimum number of 81.00 and 82.33 tubers $plot^{-1}$ were recorded in control treatment. In placement method of fertilizer application maximum number (151.67) of tubers $plot^{-1}$ were recorded, when nitrogen were applied @ 250 kg ha^{-1}. Banding method of fertilizer application yielded 5.74 and 5.22 % more number of tubers $plot^{-1}$ than broadcasting and placement methods, respectively.

Studying all the three methods of fertilizer application it is concluded that banding methods is efficient and responsive as compared to other, when nitrogen at its maximum (300 kg ha^{-1}) level. Born and Magrim (1987) also reported similar results that increasing in level causes significant increases in number of tubers $plot^{-1}$, especially of large size tubers and this is mostly marked in sandy soil. Small tubers (25 g) decreases number of tubers and subsequently in yield, when nitrogen rate increases and vice versa (Sharma and Arora 1987). Nazayuk (1987) signify that accumulation of organic matter in the soil by plant increased, when nitrogen applied through banding method. In plants green parts are considered to

photosynthetically active regions that are mainly involved in energy production to perform various metabolic function in plants. Shukla and Ramaih (1985) studied that application of nitrogen causes increases in number of green leaves, plant height and finally number of tubers.

Tuber Size

Statistically high significant variations ($P<0.01$) were observed among different methods of fertilizer application, nitrogen levels and also for interaction between them (Table II).

Averaged across seven nitrogen level and three methods of fertilizer application tuber size ranged from 32.02 to 59.12 mm in potato variety Desiree (Table II). Maximum tuber size of 63.33 and 58.67 mm were produced at 150 kg ha^{-1} nitrogen level while minimum of 32.83 and 31.55 mm at control treatment by applying banding and broadcasting methods respectively. Placement methods produced maximum (56.67 mm) and minimum (31.67 mm) tuber size when nitrogen received at 200 kg ha^{-1} and at control level. At 200 kg ha^{-1}; broadcasting, banding and placement each had the same (56.67 mm) tuber sizes, indicating stagnant performance of potato variety Desiree at this nitrogen level.

Banding method produced 6.78 and 12.21 % more increase in tuber size as compared to placement and broadcasting methods respectively. So it is concluded that after banding, placement and broadcasting ranked second and third efficient and responsive methods of fertilizer applications. Friessbleben and Thomaschewski (1988) also mentioned that yield of potato increased by 6 to 8 % when nitrogen applied through banding method. Chaudhary and Chaudhary (1991) obtained highest yield when fertilizer were applied as single or double bands at planting.

Growth Rate Or Percent Ground Cover

Data on growth rate or percent ground cover were recorded on six different dates from October 1 to December 15. Analysis of variance showed that growth rate or percent ground cover high significantly affected by various methods, levels of fertilizer applied and also for their interaction (Table III).

Maximum ground cover (59.33 %) was recorded in plots, which received fertilizer through banding followed by placement (57.50 %) and broadcasting (57.39 %). Lowest growth rate of 39.11 % were recorded for both broadcasting and banding. Plots that received nitrogen at its maximum level (300 kg ha^{-1}) performed better as compared to others (Table III). This declared that maximum level of nitrogenous fertilizer is essential for vegetative growth in potato.

Averaged across two factors growth rate ranged from 39.11 to 57.39 %, 39.11 to 59.33 % and 39.67 to 57.50 % for broadcasting, banding and placement respectively. Banding method produced 3.26 and 3.08 % more growth rate vs broadcasting and placement. Growth rate was at its peak level on November 15, and onward no improvement was observed. Wulf (1996) stated that nitrogen placement did not significantly affected emergence but tended to improve early growth. Differences in growth rate were not correlated with yield but in this study a little bit is found. Puschner (1991) suggested that better yield stability is given for banding than broadcasting.

Tuber yield

Analysis of variance showed high significant differences ($P<0.01$) among different methods of fertilizer application, nitrogen levels and also for interaction between them (Table IV).

Averaged over seven nitrogen level and three methods of fertilizer application potato yield ranged from 8.80 to 17.71 tonnes ha^{-1}. Applying banding, placement and broadcasting methods of fertilizer application respectively produced highest yield of 19.28, 17.19 and 16.65 tonnes ha^{-1}, when nitrogen @ 150 kg ha^{-1} applied (Table IV). Minimum tuber yield produced at control treatment by using broadcasting (8.95 tonnes ha^{-1}), banding (8.82 tonnes ha^{-1}) and placement (8.94 tonnes ha^{-1}) methods. For promising potato yield, banding method accompanied with 150 kg N ha^{-1} proved to be best during this study. Grawal and Sharma (1980) also suggested 150 kg ha^{-1} nitrogen for best yield in potato. Khurana and Panditha (1985) recommended 180 kg ha^{-1} nitrogen for potato best yield.

Banding method produced 5.59 and 7.86 % more production then placement and broadcasting methods respectively. Friesslaben and Thomaschewski (1988) reported that 6 to 8 % increase in potato production is possible when nitrogen and phosphorous applied in band or besides rows of seed tubers. During this study tuber size is highly correlated with potato yield as compared to number of tubers $plot^{-1}$, that's why this associated trait shared same nitrogen level and fertilizer application method.

Table I. ***Number of tubers plot^{-1} in potato variety Desiree, at ARS (N), Mingora, Swat, during autumn 1998.***

Nitrogen level (kg ha^{-1})	Methods			
	Broadcasting	**Banding**	**Placement**	**Mean**
50	110.00	115.67	118.00	114.56
100	131.33	144.33	135.67	137.11
150	134.00	147.00	146.00	142.33
200	149.33	153.33	144.00	148.89
250	154.67	162.33	151.67	156.22
300	159.00	170.33	147.67	159.00
Control	81.00	82.33	81.33	81.56
Average	**131.33**	**139.33**	**132.05**	
Fertilizer level		**		
Methods		**		
Fertilizer level × Methods		**		

Table II. ***Tubers size (mm) in potato variety Desiree , at ARS (N), Mingora, Swat, during autumn 1998.***

Nitrogen level (kg ha^{-1})	Methods			
	Broadcasting	**Banding**	**Placement**	**Mean**
50	33.33	38.67	36.67	36.22
100	33.34	55.67	53.33	47.45
150	58.67	63.33	55.35	59.12
200	56.67	56.67	56.67	56.67
250	40.33	43.33	36.67	40.11
300	33.33	36.67	34.67	34.89
Control	31.55	32.83	31.67	32.02
Average	**41.03**	**46.74**	**43.57**	
Fertilizer level		**		
Methods		**		
Fertilizer level × Methods		**		

* = Significant at 0.5 % level of probability
** = Significant at 0.1 % level of probability
NS = Non significant

Table III. ***Data on percent ground cover or growth rate in potato variety Desiree, at ARS (N), Mingora, Swat.***

Methods	Nitrogen levels (kg ha^{-1})	Dates						Mean
		Oct. 1	Oct.15	Nov. 1	Nov.15	Dec.1	Dec.15	
	50	25.00	39.00	56.00	65.00	60.00	19.33	44.06
Broadcast	**100**	25.33	44.00	60.00	71.00	62.00	20.33	47.28
	150	28.67	49.00	70.67	85.33	62.33	20.67	52.78
	200	24.33	50.67	74.67	87.33	68.33	19.00	54.06
	250	21.67	52.00	76.00	90.66	71.66	22.33	55.72
	300	22.67	52.33	79.00	91.66	77.67	21.00	57.39
	0	22.33	36.33	51.33	60.00	46.67	18.00	39.11
	50	20.33	40.00	57.00	66.00	58.00	22.00	43.89
Banding	**100**	28.00	42.00	60.33	73.67	61.33	19.00	47.39
	150	28.33	51.33	73.33	89.33	72.67	19.00	55.67
	200	28.33	53.00	74.33	90.67	70.00	19.67	56.00
	250	24.33	54.67	78.33	91.33	77.00	20.67	57.67
	300	24.67	55.67	83.00	91.33	80.33	21.00	59.33
	0	20.33	37.67	51.00	59.67	48.67	17.33	39.11
	50	24.00	38.67	54.67	65.33	50.00	22.33	42.50
Placement	**100**	23.33	42.67	62.33	72.33	62.66	21.00	47.39
	150	26.33	45.33	67.33	87.00	63.33	21.00	51.72
	200	25.33	52.33	70.67	87.67	71.33	18.33	54.28
	250	24.00	51.00	77.67	91.00	75.67	22.33	57.44
	300	25.67	54.33	80.67	90.33	75.00	19.00	57.50
	0	26.00	36.33	50.00	59.33	49.67	16.66	39.67
Average		**24.86**	**46.59**	**67.06**	**79.34**	**64.98**	**20.00**	
Fertilizer level				**				
Methods				**				
Fertilizer level × Methods				**				

* = Significant at 0.5 % level of probability
** = Significant at 0.1 % level of probability
NS = Non significant

Table IV. ***Tuber yield tonnes ha^{-1} in potato variety Desiree, at ARS (N), Mingora, Swat, during autumn 1998.***

Nitrogen level (kg ha^{-1})	Methods			
	Broadcasting	Banding	Placement	Mean
50	11.30	12.39	11.81	11.83
100	13.29	16.41	15.36	15.02
150	16.65	19.28	17.19	17.71
200	16.36	17.06	15.14	16.19
250	14.08	14.87	14.15	14.37
300	13.68	13.53	13.65	13.62
Control	8.95	8.82	8.94	8.80
Average	**13.47**	**14.62**	**13.75**	
Fertilizer level		**		
Methods		**		
Fertilizer level × Methods		**		

REFERENCES

Anonymous. 2001. Northern Areas Agriculture Statistics 2001. Department of Agriculture, NA, s and FAO of the UN, Gilgit. pp. 61.(UN-PAK FAO/2001/2003).

Anonymous. 2003. Agricultural Statistics of Pakistan (2001-2002) MINFAL.GOP, Islamabad. pp. 289.

Born, M., and L. Margrim, 1987. Effect of n fertilizer and soil type on potato tuber formation. Potato Abst.12(12):196.

Chaudhary, M.A.H., and A.K.M.S.H. Chaudhary, 1991. Pak. J. of sci. and Industrial Res. 34(2): 98-100.

Friessalben, G., and H. thomaschewski, 1988. Primary result of the experiments on loosing and placing fertilizers underneath potato. Germen Inst. Fur Kartoffelforschung, Grass Lusenitz. Pp.53-57. (CAB. Abst. 1990-91, AN:G327943).

Gomez, K.A. and A.A. Gomez. 1983. Statistical procedures for agricultural research. John Wiley and Sons, New York.

Grawal, J.S., and R.C. Sharma, 1980. Fertilizer needs of potato. Fertilizer News. pp. 49-59.

Haris, P.M. Trends in potato production. The potato crop, the scientific information for improvement. (ed. P.M. Harris, Second Edition). Chapman and Hall, London.. 2(13):796-799.

Hawkes, J.G. 1967. The history of potato. J. Royal Hort. Soc. 92:207-224.

Khurana, S.C., and M.L. Panditha. 1985. Effect of nitrogen andpotassiumon growth and developmentofpotato. J. of Indian Potato Assoc. 12(3-4):17-180

Nazaryuk, V.M. 1987. Placement of N fertilizers in bands in vegetables and potatoes. Information of yield and quality. Agrokhimiya. 2:7-17.

Puschner, C., 1991. Deep placement of NP fertilization. Karfoffelban. 42(3):22-25. (CAB abst. 1993-94, AN:NO105518).

Sharma, U.C., and B.R. Arora, 1987. Effect of nitrogen, phosphorous and potassium application on yield of potato tubers. J. of Agric. Sci. UK.108(2):321

Shukla, D.N., and N.V. Ramaih. 1985. effect of nitrogen, potassium and cycocel on growth in relation to yield in potato. J. of Indian Potato association. 12(3-4):115-121.

Wulf, B. 1996. Fertilizer placement for potato. Kartoffelban. 47(3): 86-90. (CAB. Abst. 1996-98, AN:960710376).