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Effect of potassium, zinc and farm yard manure on growth, yield, nutrient uptake and quality of potato (*Solanum tuberosum* L)

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Abstract
A field experiment was conducted at Gwalior (M.P.) for two consecutive years to study the effect of potassium, zinc and farm yard manure on growth, yield, nutrient uptake and quality of potato. The experiment consisted of 3 levels of FYM, 3 levels of zinc and 5 levels of potassium. The experiment was conducted under split plot design with three replications. The results revealed that application of 80 kg K/ha, 25 kg Zn SO_4/ha and 10 t FYM/ha recorded significantly higher value for yield and yield attributes. Application of 80 kg K/ha, 10 t FYM/ha and 25 kg Zn/ha recorded significantly higher values for almost for all the parameters. Application of 120 kg K/ha, 5 t FYM/ha and 25 kg Zn/ha significantly improved quality parameters. Application of FYM @ 5 t/ha and Zn @ 25 kg /ha significantly increased NPK content in haulm and tubers. There was significant increase in NPK uptake due to application of 120 kg K, 10 t FYM and 50 kg Zn/ha. Application of potassium, FYM and Zn recorded more nutrient-N, P and K content in soil as compared to previous doses. B: C ratio value was 3.6 due to application 120 kg K_2O, 10 t FYM and 25 kg Zn SO_4/ha.

Keywords: growth, potato yield, nutrient uptake, potassium FYM zinc, quality

Introduction

India ranks 2nd in area and production of potato in the world after China, which contributes 11 per cent of world potato production (FAO STAT, 2014). In India, potato production is mainly confined to Uttar Pradesh, West Bengal, Bihar, Madhya Pradesh, Gujarat, Punjab, Assam and Haryana. In India, it is grown in an area of 2 million hectares and the total production is 44.3 million tonnes (Anonymous, 2015) [1]. Productivity of Gujarat was (29750 kg/ha) highest in India among potato growing states (Anonymous, 2015) [2]. It is highly nutritious food as it provides carbohydrates, minerals, vitamin C and a number of B Group vitamins and high quality dietary fibers. Thus, potato is a nourishing and whole some food and also rich in lysine and now a days the meal without potato is considered incomplete (Ezekiel *et al*, 1999) [9].
Potato demands high level of soil nutrients due to relatively sparse root system. Potato crop has strict requirement for a balanced nutrition, without which growth and development of the crop will remain poor and both yield and quality of tubers would be affected adversely. Among the major nutrients, potassium not only increases yield but also improves various quality parameters. It has a crucial role in the translocation and storage of assimilates to different parts (Marschner, 1995) [11]. Potato absorbs zinc in ionic form. Zinc is involved in the synthesis of indole acetic acid (IAA), metabolism of gibberlic acid and synsthesis of RNA. Because of its potential binding of sulphydryl group, zinc plays an important role in the stabilization and structural orientation of the membrane proteins.

Since high input agriculture had degraded soil productivity and environmental quality, use of organic sources is one of the options in crop production and FYM is a good source. Farm yard manure is bulky in nature and supplies large quantity of organic matter. The value of FYM in soil improvement is due to its nutrients content and its ability to improve soil tilth and aeration. Additionally, it increases water holding capacity of the soil and stimulates the activity of microorganisms that make the plant nutrients in available form.

Under normal production technology, farmers use non judicious chemical fertilizers to obtain the high commercial yield. The chemical fertilizers alone may deteriorate the soil health and create nutrient imbalance.

Application of organic fertilizers alone does not produce spectacular increase in the yield due to their low nutrient status and requirement in huge quantity. Hence, this investigation was planned to study the influence of chemical and organic fertilizers on growth and tuber yield.

Materials and Methods

Field experiment was conducted during the *rabi* seasons for two consecutive years at Central Potato Research Station, Gwalior (M.P.). The site was situated at $26^0$13' N latitude, $26^0$14' E longitude and on altitude of 211.52 m above mean sea level. The soil was silty clay loam, low in organic carbon (0.29 and 0.39%), available nitrogen (192.0 and 195.5 kg/ha), phosphorus (16.90 and 17.20 kg/ha) and high in potassium (206.2 and 213.6 kg/ha) with pH 7.80 and 7.74 during first and second year, respectively. The treatments consisted of three levels of farm yard manure (0, 5 and 10 t/ha), five potassium levels (0, 40, 80, 120 and 160 kg/ha) and three levels of Zn (0, 25 and 50 kg/ha). These treatments were evaluated in split plot design allocating organic manure and potassium in main plot and zinc in sub plot. Treatments were replicated three times.

Potato variety 'Kufri Pukhraj' was planted at 60 cm row spacing and 20 cm tuber to tuber spacing using a seed rate of 3.5 t/ha. Prior to planting, the field was prepared as per the standard procedure. On the next day of planting, Metribuzin @ 500 g a.i./ha was applied in each treatment. The recommended dose of N, P_2O_5 and K_2O was applied @ 180, 80 and 120 kg/ha, respectively. Potassium fertilizer was applied as per treatment. Half dose of nitrogen and full dose of P, K and Zn were applied as basal at the time of planting and remaining half dose of nitrogen at the time of earthing up (30 DAP).

FYM (N 0.47%, P_2O_5 0.25% and K_2O 0.54%) was mixed in soil at the time of field preparation as per treatment. Total amount of rain fall during the crop growth period was 4.0 and 0.0 mm in first and second year, respectively. Plant and soil samples were analyzed for nutrient content as per standard procedure. The results were statistically analyzed.

Result and Discussion

Growth attributes: Application of FYM, potassium and zinc could not exert any significant effect on emergence of potato tubers. Potassium application increased plant height significantly upto 80 kg/ha. Application of 5 t FYM/ha increased plant height significantly over control. However, further increase in FYM dose did not show any significant effect on plant height. Application of zinc @ 25 kg/ha increased plant height significantly over control. Further increase did not show any significant effect. Application of potassium increased number of leaves per plant significantly upto 80 kg/ha. Application of FYM significantly increased number of compound leaves. Application of zinc increased leaves/plant significantly up to 25 kg/ha only. Application of potassium up to 40 kg/ha significantly increased stem/plant however further increase in potassium did not exert any significant effect. Application of FYM increased number of stem/plant significantly upto 10 t/ha. Application of Zn up to 25 kg/ha increased stem/plant significantly but did not show significant effect with further increase in Zn dose. Canopy cover increased with increasing doses of potassium however it was significant only up to 80kg/ha. Increasing dose of FYM and Zn (up to 25 kg/ha) application also increased canopy cover significantly. The increase in growth attributes may be due to improved nutritional status of the soil.

Yield attributes and yield

Production of small size tubers was on par in all the treatments due to application of K, FYM and Zn. Increasing application of K from 0 to 80 kg/ha significantly increased number of medium size tubers. Further increase in potassium did not show any significant increase in number of tubers. Application of FYM increased number of medium size tubers significantly. Application of Zn significantly increased number of medium size tubers.

Similarly, application of potassium increased number of large size tubers significantly upto 80 kg/ha, however, further increase in potassium dose did not show any significant effect on number of large size tubers. Application of FYM significantly increased the number of large sized tubers. Application of Zn @ 25 kg/ha significantly increased number of large size tubers over no Zinc however it was on par with 50 kg Zn/ha.

Application of potassium increased total number of tubers significantly up to 80 kg/ha. Application of FYM significantly increased total number of tubers. In case of Zn application, total number of tubers increased significantly up to 25 kg Zn/ha. Sharif Ahamad *et al*. (2014) reported advantageous effect due to application of FYM in combination with K as it improves tuber yield significantly by way of improving soil physical properties and also maintaining a positive nutrient balance and also helps in keeping quality of the tubers.

Increasing dose of potassium up to 80 kg/ha increased yield of small size tubers significantly. Application of FYM did not show any systematic trend on production of small size tubers. Application of Zn increased production of small size tubers significantly. Application of potassium significantly increased yield of medium size tubers upto 80 kg/ha. Application of FYM significantly increased production of medium size tubers. Similarly, application of Zn increased production of medium size tubers significantly. Application of potassium up to 80 kg/ha significantly increased yield of large size tubers. Application of FYM increased production of large size tubers significantly up to 5t/ha. Application of Zn @ 25 kg/ha increased production of large size tubers significantly. Application of potassium up to 120 kg/ha significantly increased total tuber yield however further increase in dose did not show any significant effect. Application of FYM @ 5 t/ha significantly increased total tuber yield. Application of Zn increased total tuber yield significantly up to 25 kg/ha. Philip *et al*. (2012) [13] found that bio-fortification of tubers with Zn was restricted by the limited mobility of Zn in the phloem. A significant positive linear relationship between tuber Zn concentration and tuber N concentration supported the hypothesis of co-transport of Zn and N-compounds in the phloem. Higher tuber yield under potassium application may be due to positive effect of K on tuber size which might haveresulted in higher number of large and medium size tubers. Tuber development at later stages due to translocation of photosynthates from leaves to tubers is also influencd by K which increases the rate and duration of tuber bulking. These results corroborate the findings of Singh and Bansal (2000) [17] and Mondal *et al.* (2007) [12].

Application of FYM resulted in increase in production of large and medium sized tubers due to the fact that application of FYM improves the physical, chemical and biological environment of soil. It provides major, secondary and micronutrients to the crop resulting in better crop growth and ultimately the yield. These findings are in line with the results of Chettri and Tapas (2004) [4], Mondal *et al.* (2007) [12] and Lal and Khurana (2007) [10].

Application of Zn increased tuber yield which might be due to the role of Zn in biosynthesis of IAA and especially its role in initiation of primordiafor reproductive parts which might have resulted in increase in tuber size. Similar findings were reported by Sharma *et al.* (1998) and Trehan and Grewal (1995).

Tuber dry matter

Increasing dose of potassium significantly increased dry matter content of tubers up to 80 kg/ha. Increasing application of FYM significantly increased tuber dry matter content. Application of Zn up to 25 kg/ha increased dry matter content significantly.

Starch content

Application of potassium significantly increased starch content of tubers up to 80 kg/ha. Potassium enhances starch formation and its translocation into tubers. Similar improvement in starch content of tubers has also been reported by Dan and Thind (2005) [5].

FYM application increased starch content of tubers significantly. Sharif Ahamad *et al*. (2014) reported advantageous effect due to application of FYM in combination with K as it improves tuber yield significantly and also helps in keeping quality of the tubers.The results are in agreement with the findings of Dan and Thind (2005) [5]. Application of Zn also significantly increased starch content of tubers. Philip *et al*. (2012) [13] found that bio-fortification of tubers with Zn was restricted by the limited mobility of Zn in the phloem. High levels of phosphorus in plants have been shown to restrict movement within the plant, resulting in accumulation in the roots and deficiency in the tops. Therefore, large applications of phosphorus fertilizer may contribute to zinc deficiency in zinc-responsive crops.

Nutrient content

In case of tuber N content, it increased significantly due to application of potassium up to 80 kg/ha. Application of potassium up to 40 kg/ha resulted in significant increase in P content of tuber and haulm. K content increased significantly due to application of potassium up to 80 and 120 kg/ha in haulm and tubers, respectively. Similar findings have been reported by Dubey *et al.* (1997) and Dan and Thind (2005) [5].

Application of FYM resulted in significant increase in haulm N content however in case of tuber, application of FYM increased N content up to 5 t/ha. Application of FYM increased P content of haulm and tuber up to 10 t/ha, Application of FYM exerted significant increase in K content in haulm up to 10 t/ha and in case of tuber up to 5 t/ha. It might be due to the fact that FYM improves the soil environment which encourages proliferation of roots which draw more water and nutrients from larger area and also from greater depth. Roy *et al*. (2001) [14] also reported that NPK contents significantly increased with FYM application.

Application of zinc increased NPK content of haulm and tuber up to 25 kg Zn /ha. It may be due to favorable influence of Zn which ultimately increased concentration of nutrients in haulm and tuber. The results are in accordance with the findings of Sharma and Bhardwaj (1998) [14] and Dwivedi *et al.* (2001) [7].

Nutrient uptake

Application of potassium from 0 to 120 kg/ha significantly increased N uptake. Increasing level of potassium significantly increased phosphorus uptake. Application of potassium increased potassium uptake significantly up to 120 kg k/ha. Increasing application of FYM significantly increased nitrogen, phosphorus and potassium uptake. Application of zinc increased N uptake only up to 25 kg Zn/ha. Application of Zn significantly increased P and K uptake at all the levels**.**

NPK uptake increased with the application of potassium, FYM and Zn to crops because of higher availability of these nutrients and higher biomass. These results are in accordance with the findings of Swarup and Srinivasa Rao (1999), Sharma and Bhardwaj (1998) [14] and Dwivedi *et al.* (2001) [7].

Table 1: Nutrient content, uptake and nutrient status as influenced by potassium, zinc and FYM levels (pooled data for two years)

Treatment	Nutrient content (%)						Total Uptake (kg/ha)			Nutrient status of soil (kg/ha)				
	Haulm			Tuber										
	N	P	K	N	P	K	N	P	K	OC	N	P	K	Zn
K_0	0.18	0.09	0.38	1.82	0.36	1.87	64.4	15.64	83.63	4.3	184.4	16.51	195.7	0.42
K_{40}	0.24	0.14	0.58	2.11	0.42	2.19	112.34	27.54	137.08	4.36	188.5	17.62	206.7	0.51
K_{80}	0.28	0.17	0.65	2.55	0.45	2.32	134.35	34.6	163.87	4.42	193.4	18.53	221.5	0.58
K_{120}	0.32	0.21	0.68	2.34	0.47	2.46	149.1	39.91	177.35	4.52	196.6	19.44	236.8	0.64
K_{160}	0.34	0.23	0.71	2.37	0.49	2.49	154.98	42.85	184.66	4.56	197.8	20.65	247.2	0.66
SEm ±	0.02	0.01	0.02	0.04	0.009	0.04	2.95	0.68	2.44	0.05	1.97	0.14	3.07	0.02
CD5%	0.06	0.03	0.06	0.13	0.03	0.11	9.61	2.23	7.95	0.18	6.41	0.46	10.01	0.07
No FYM	0.21	0.12	0.49	2.05	0.38	2.14	102.18	23.27	122.17	4.31	187.5	16.92	201.4	0.48
FYM @ 5t/ha	0.24	0.18	0.58	2.2	0.46	2.32	119.02	32.2	147.06	4.46	202.3	18.43	224.1	0.58
FYM @ 10t/ha	0.28	0.21	0.64	2.3	0.49	2.36	135.1	37.58	162.81	4.52	208.4	20.45	239.3	0.62
SEm ±	0.01	0.01	0.02	.05	0.011	0.03	1.83	0.42	2.37	0.03	1.12	0.13	3.26	0.01
CD5%	0.03	0.03	0.05	0.14	0.04	0.08	5.41	1.24	7.00	0.1	3.31	0.37	9.62	0.04
Zn_0	0.21	0.14	0.44	2.02	0.38	2.16	104.46	25.15	124.14	4.33	190.5	19.62	208.	0.45
Zn_{25}	0.29	0.18	0.62	2.14	0.46	2.28	124.73	33.04	151.95	4.44	201.4	18.41	222.8	0.56
Zn_{50}	0.32	0.19	0.66	2.15	0.48	2.36	131.66	35.81	162.8	4.51	206.4	17.65	233.7	0.68
SEm ±	0.01	0.01	0.02	0.04	0.015	0.03	2.55	0.47	2.75	0.05	2.63	0.14	3.76	0.01
CD5%	0.04	0.02	0.05	0.11	0.04	0.09	7.21	1.32	7.77	0.13	NS	0.41	10.65	0.04

Table 2: Economics of different treatments as influenced by Potassium, Zinc and FYM levels (two years pool data)

Treatment	Economics (Rs /ha)			B: C ratio
	CC	GR	Net return	
K0F0Z0	71700	221996	150296	3.1
K0F5Z0	72533	224893	152360	3.1
K0F10Z0	73366	228030	154664	3.1
K0F5Z25	73700	229043	155343	3.1
K0F10Z50	75700	235223	159523	3.1
K0F0Z25	72866	226146	153280	3.1
K0F0Z50	74033	229190	155157	3.1
K0F5Z50	74866	232086	157220	3.1
K0F10Z25	74533	232180	157647	3.1
K40F0Z0	71811	249036	177225	3.5
K40F5Z0	72644	251933	179289	3.5
K40F10Z0	73477	255070	181593	3.5
K40F5Z25	73811	256083	182272	3.5
K40F10Z50	75811	262263	186452	3.5
K40F0Z25	72977	253186	180209	3.5
K40F0Z50	74144	256230	182086	3.5
K40F5Z50	74977	259126	184149	3.5
K40F10Z25	74644	259220	184576	3.5
K80F0Z0	71922	255653	183731	3.6
K80F5Z0	72755	258550	185795	3.6
K80F10Z0	73588	261686	188098	3.6
K80F5Z25	73922	262700	188778	3.6
K80F10Z50	75922	268880	192958	3.5
K80F0Z25	73088	259803	186715	3.6
K80F0Z50	74255	262846	188591	3.5
K80F5Z50	75088	265743	190655	3.5
K80F10Z25	74755	265836	191081	3.6
K120F0Z0	72033	258523	186490	3.6
K120F5Z0	72866	261420	188554	3.6
K120F10Z0	73700	264556	190856	3.6
K120F5Z25	74033	265570	191537	3.6
K120F10Z50	76033	271750	195717	3.6
K120F0Z25	73200	262673	189473	3.6
K120F0Z50	74366	265716	191350	3.6
K120F5Z50	75200	268613	193413	3.6
K120F10Z25	74866	268706	193840	3.6
K160F0Z0	72144	259890	187746	3.6
K160F5Z0	72977	262786	189809	3.6
K160F10Z0	73811	265923	192112	3.6
K160F5Z25	74144	266936	192792	3.6
K160F5Z50	75311	269980	194669	3.6
K160F0Z25	73311	264040	190729	3.6
K160F0Z50	74477	267083	192606	3.6
K160F5Z50	75311	269980	194669	3.6
K160F10Z25	74977	270073	195096	3.6

Nutrient status of soil

Increasing potassium and zinc application increased organic carbon content of soil. Application of FYM upto 5 t/ha increased organic carbon content significantly over control. Indirectly, it may be due to effect of potassium, FYM and Zn on the returns of organic material in the form of crop residues particularly crop roots and leaf fall and direct addition of organic matter through FYM. The results also confirm the findings of Bhardwaj and Omanwar (1994) [3].

Application of potassium increased nitrogen content of soil significantly over no K application at different levels except 40 kg/ha. Application of FYM significantly increased N content upto 10t/ha and there was no significant effect of Zn application on N content of soil. These results also confirm the findings of Kamat *et al.* (1982) [11] and Roy *et al.* (2001) [14].

Application of potassium also increased phosphorus content of soil significantly. Similarly application of FYM also significantly increased phosphorus content of soil, however application of Zn decreased P content significantly. Application of potassium significantly increased potassium content of soil. Similar trend was observed in case of FYM and Zn application. Application of potassium, FYM and Zn significantly increased Zn content of soil. Similar results were reported by Singh and Bansal (2000) [17]. Sharif Ahamad *et al.* (2014) reported advantageous effect due to application of FYM in combination with K as it improves tuber yield significantly by way of improving soil physical properties and also maintaining a positive nutrient balance and also helps in keeping quality of the tubers.

Economics

Cost of cultivation increased with increasing application dose of potassium, FYM and Zn. Increasing dose of potassium, FYM and Zn increased net return and B: C ratios. Highest cost of cultivation (Rs 76033/ha) was recorded with the application of 120 kg K_2O, 10 t/ha FYM and 50 kg Zn/ha. Highest gross return (Rs 2,71,750) was recorded with the same treatment. Similarly, highest net return (Rs 1,95,717/ha) and B : C ratio (3.6) were recorded with the same treatment.

Hence, on the basis of above findings it is concluded that application of 120 kg K_2O in combication of 10 t FYM/ha and Zn @ 25 kg/ha gave highest tuber yield, gross return and B : C ratio is most desirable treatment.

On the basis of above findings it can be concluded that different potassium, FYM and Zinc levels significantly influenced the growth and yield attributes, yield and quality of potato. The effect of FYM application is beneficial for enhancing tuber yield, tuber quality, nutrient NPK uptake by crops, soil fertility *viz* OC, available NPK and Zn contents as compared to without FYM. Application of Zn @ 25 kg/ha is essential for obtaining higher tuber yield with highest net return and B: C ratio.

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