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Review Article

EFFECT OF FERTILIZERS ON GROWTH AND PRODUCTIVITY OF POTATO- A REVIEW

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Abstract- Potato originated in the Peru-Bolivian region in the Andes (South America), largely raised in cool regions where the mean temperature of the growing season does not exceed 18^{0}C. It is the third most important food crop after wheat and rice. Potato is a heavy feeder crop and hence needs heavy doses of fertilizers for its growth and yield. Obviously, nutrient management shall be an essential aspect in the management of potato crop. It is the art of managing the amount, form, placement and timing of application of nutrients to plants. However, integrated nutrient management is essential tools for balanced fertilization and sustainability of crop production on long term basis. This review gives an account of nutrient management carried out on potato crop for optimization of potato growth and tuber yield.

Key Words- Potato, Fertilizer, Nutrient Management, Growth, Productivity

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Introduction

Potato (*Solanum tuberosum* L.) belongs to night shade family Solanaceae having chromosome number (2n=4X=48) is an important food crop of the world and also a very popular vegetable crop. It is the "food of Future". Potato tuber contains 70-82 % water,17-29% dry matter, 11-23% carbohydrate, 0.8-3% protein, 0.1% fat and 1.1% minerals. Potato is the rich source of starch, vitamin C and B and minerals. It also contains good amount of essential amino acids like leucine, tryptophan and isoleucine [1]. Potato contains high protein -calories ratio(17g protein:1000 Kcal) and yields more edible energy, protein(3 kg/ha/Day) and dry matter per unit area and time (47.6kg/ha/day) compared to cereals [2].

Potato is grown and consumed all round the world and is one of the main vegetable cash crop [3]. It is the third most important food crop after wheat and rice because of its great yield potential and high nutritive value [4]. It is among the major food crops grown in more than 100 centuries in the world [5]. China leads the world in potato production and nearly one third of potatoes are harvested in China and India. India ranks second to China with area, production and productivity of about 1.97 m ha, 41.55 million tons and 21.1 t/ha respectively [6].

Potato is a heavy feeder crop and hence needs heavy doses of fertilizers for its growth and yield. It also demands high level of soil nutrients due to relatively poorly developed and shallow root system in relation to yield. Potato produces much more dry matter in shorter cycle hence requires large amount of nutrients per unit time, which generally most of the soils are not able to supply. Hence, nutrients from external sources as fertilizer became essential. Balanced and timely supply of fertilizer is a pre-requisite for getting optimum yield potential of potato [7]. Proper nutrient management is essential to maximize potato production and sustain agricultural production while minimize negative impact on soil fertility [8].

Effect of Nitrogen on growth and yield of potato:

Nitrogen fertilizer increased the leaf area which increases the amount of solar radiation intercepted and consequent, increases days to flowering, days to Physiological maturity, plant height and dry matter production of different plant parts [9]. Similarly, the potato crop requires high amounts of nitrogen for optimum yields [10]. A mature potato crop, yielding 25-30 t/ha usually removed 120 to 140 Kg N/ha. He also reported that higher rate of nitrogen provides better growth, development and translocation of photosynthetic from source to sink (tuber) which resulted in higher yield of tubers [11]. The effects of different grades of nitrogen and crop duration on the bulking properties of potato varieties K. Sutlej were determined that all growth parameters like plant height, number of stems per hill, leaf fresh weight and yield parameters like number of tubers per hill, dry matter content, yield of different grade tubers, mean total tuber yield and tuber bulking increased with increasing rates on N [12]. Likewise, the covering with nitrogen application resulted in an increase of the dry matter content in tubers by 1.29% and starch by 0.45% [13].

Application of 25t/ha organic manure along with 100% recommended dose of nitrogen in inorganic form or more than 50% of recommended dose of nitrogen in inorganic form and remaining parts of nitrogen in caster cake or poultry manure increased the chlorophyll content, tuber yield, tuber dry matter and minimized storage losses and improved quality of chips [14]. Application of 100% N of recommended dose also boosted the growth and yield of potato. However, highest tuber yield and net return was obtained with application of FYM @ 15 t/ha + Azotobacter + 100% recommended dose of nitrogen [15].N level increased, auxillary branch number, plant height increased and the maximum stem and leaf biomass and leaf number was achieved with 160 Kg N/ha and highest main stem number was achieved in 80 kg N/ha [16]. There is a linear relationship between yield of tubers per hectare and the different levels of nitrogen, hence reported the increase in tuber yield with the application of higher levels of nitrogen[17].A significant increase in tuber yield was recorded with the increase in the dose of nitrogen[18].The maximum number of tubers, tuber weight and number of stems with application of highest dose of nitrogen i.e. 200kg/ha of N for the variety Agria during the year 2012 [19].The highest yield of tuber 39.83 t/ha was obtained when crops were applied with225 Kg N and 150 kg of K_2O/ha against a tuber yield of only 14.36 t/ha without application of any fertilizer for the variety Kufri Pukhraj [20].

On the other hand, Excessive application of nitrogen leads to delayed maturity, poor tuber quality and occasional reduction in tuber yield [21]. Argonomic N use efficiency (118.6-66.0 Kg tubers/kg N applied) decreased linearly with increase in N levels for the cultivar K. Anand and K. Pukhraj [22]. Chip colour is also darkened with application of higher dose of nitrogen [23]. High use of N and less use P and negligible use of K fertilizers and micronutrients led to nutrient imbalances in soils and lower nutrient use efficiency and economic profitability [24,25].

However, the potato gave optimum tuber yield when N fertilizer was applied at the rate of 204 kg/ha and yield reduction was noted when applied above this rate [26]. There was also decrease in the dry matter beyond 200 kg N/ha, which might be due to difference in relative maturity of tubers [27]. The results of the experiment conducted by Georgakis et al. during the year 1997 showed that increase in nitrogen rates up to favorite point led to increase in tuber yield per unit area beyond which the rate decrease [28]. This might be due to the fact that vegetative growth of the aerial parts can increase with application of more Nitrogen and hence, inhibit transferring photo synthetically matters into the storage parts (tubers).

The lower dose of Nitrogen (80 kg ha^{-1}) and plant density of 11 plants per m^2results high edible quality and high yield of tuber along with lowest nitrate pollution in soil and underground water [29]. Similarly, The tuber yield per unit area was increased with increasing nitrogen fertilizer up to suitable level [30, 31].

So, it is concluded that nitrogen is important for a heavy feeder crop like potato. N deficiency is characterized by yellowing of leaves, stunted growth and lower yield. Application of nitrogen plays a key role in crop growth of potato and development resulting in increased size and number of processing and no-processing grade tubers ultimately enhancing total yield. However, there must be optimization of nitrogen application beyond which it will not respond.

Effect of P on growth and yield of Potato:

The presence of sufficient quantity of phosphorus caused beneficial response in improvement of haulms per plant [32]. The yield response to increasing levels of fertilizer was generally positively up to particular level, above which the response became negative. They also noted that excess use of P fertilizers is usually associated with reduced tuber weight by hastening the maturation period and reducing tuber size [33]. Phosphorus is a part of the nucleic acid which is very important for seed and fruit formation and root growth. Phosphorus also is responsible in increasing the number of leaves in the early stages of plant growth [34]. Phosphorus is also responsible for energy transfer necessary for metabolic processes within the plant [35]. Similarly, the phosphorus uptake was significantly reduced with the application of zinc which may be due to antagonistic effect of Zn on P availability and its uptake by the crop. The treatment without K not only adversely affected the K uptake but also uptake of N and P because of lower yield and reduced concentration of nitrogen and phosphorus [36].

So, it is concluded that phosphorus is especially important for early plant development and rapid tuber growth of potato. It plays an important role in plant nutrition particularly it helps to increase early crop growth. It is also responsible for energy transfer which is necessary for metabolic processes within the plant.

Effect of K on growth and yield of Potato:

The potato crop feeds heavily on soil potassium and the tuber removed 1 to 5 times the amount of nitrogen and 4 to 5 times the amount of phosphate. Potato also acts as an indicator crop for K availability because of its high K requirement [37]. Potassium also allowed the crops to adopt to environmental stress and promoted plant tolerance to insect infection and resistance to fungal disease. Moreover, potash fertilizer reduced frost injury and enzymatic browning [38, 39].

On an average, the potato crop, yielding about 29 t ha^{-1}, removed about 91 kg K_2O ha^{-1}[40].Potassium was considered as an integral component of the balanced fertilization of potato crop to improve yield as well as quality of the tuber [41]. Supply of potassium strengthens stems to prevent lodging, increases yield and improves tuber quality [42]. It also promotes large size of tubers by the increasing water accumulation in tubers resulting in higher tuber yield [43]. Application of K increased the size of the tubers so it increases the yield by increasing the number of large sized tubers [44]. As compared to low K rate, the higher K rate application increased the yield of medium (28-60mm) and oversized (>60mm) tubers by approximately 15% and 40% respectively [45]. Potassium application at 150 Kg K_2O/ha proved to be optimum dose for most of the parameters studied [46]. Application of 100 kg K2O/ha as MOP significantly increased number as well as tuber yield of large (>75g) and medium large (50-75g) tubers which resulted in increase in overall tuber yield as well as marketable yield in potato var. Kufri Pukhraj [47]. K affected potato quality and yield and insufficient K resulted in reduced potato yield and smaller sized tubers [48].

However, the yield of medium grade tubers was increased but that of small grade tuber was not affected by progressive application of K fertilizers [49-51]. An increase in tuber yield was noticed with increasing K application rates up to the highest rate. Higher B:C ratio at higher dose of potash was due to high gross and net return from the cultivation [52,53]. The yield performance of the genotypes was truly reflected in the net economic returns with 150 kg K_2O ha^{-1}proving the optimum K level. However, return per rupee invested and net production value showed a reverse trend, with 75 kg K_2O ha^{-1}proving as the best k application rate [54].

The dry matter of potatoes decreased with increasing K level. Excess K fertilizer was reported to reduce dry matter or specific gravity [55]. The potassium is important in carbohydrate formation and in the transformation and movement of starch from potato leaves to tuber [56]. The level of potash increased there was a decrease level of reducing sugar and browning of chips as well. On the other hand, higher potash levels increased the percentage of fat content and recovery of chips [57].

While considering the application of potassium it is concluded that potassium is essential for carbohydrate synthesis and in translocation and movement of starch from leaves to tubers. It increases both the rate and duration of bulking and also allowing the crops to adopt to environmental stress and promoting plant tolerance to insect infection and resistance to fungal disease. Moreover, potash fertilizer reduced frost injury and enzymatic browning too.

Effect of NPK on growth and yield of Potato

The uptake of fertilizer nutrients (NPK) by potato per unit area and time is quite high due fast rate of early growth and tuber bulking [58]. There is beneficial effect of combined application of organic and inorganic sources of nutrient on tuber bulking rate of potato [59].The combined application of neem seed powder @ 1.2 t ha^{-1}, karanj cake @ 1.0 t ha^{-1}, farm yard manure @ 6 t ha^{-1}, commercial formulation Biomax @ 0.6 t ha^{-1} and biomas @ 1.5 t ha^{-1} along with 75% of recommended dose of NPK fertilizers (RDF) increased the tuber yield by 5.87% to 10.56% over the control (100% RDF) [60]. Adequate supply of nutrient either through chemical fertilizers or 75% NPK through chemical fertilizers and remaining 25% N through FYM was mainly responsible for increasing the number of tubers/plant and tuber weight that ultimately resulted in high potato tuber yield [61]. The highest tuber yield (321 q ha^{-1}) was recorded with 100% recommended dose of NPK fertilizers and was significantly higher than all other treatments [62]. Balanced nutrient through integrated use of greater proportion of chemical fertilizers (75% RDF) along with 25% of fertilizer through FYM might be adequate for increasing plant height, stem number and stem girth [63].

Keeping the soil health and sustainability of production system in view, the integrated use of inorganic fertilizers and organic manures i.e. 75% of recommended dose of NPK through inorganic source and 25% from FYM (on N basis) is suggested by Kumar et al.,2008. Similarly, The potato variety Kufri Megha receiving RDF or 75% RDF +25% recommended dose of nutrient through FYM produced the highest tuber yield [64].Growing of Kufri Megha with 75% RDF through chemical fertilizers and 25% RDN through FYM along with 100% RDF through chemical fertilizers for better growth, greater tuber yield and higher profit from potato[65].

The highest B:C ratio (1.34 and 1.29) was also recorded in recommended dose of NPK treatment [66]. Integrated use of inorganic and organic sources of nutrients significantly improved the yield of potato. Application of bio fertilizers gave the additional benefits and vermicompost proved better than FYM in improving the yield of potato Shalimar-1 [67]. The best treatment combination was with application of 50% recommended dose of fertilizer(NPK) through inorganic

fertilizers and 50% RDN through poultry manure along with combination of Azatobactor +PSB [68].The highest yield (25.2 t/ha) was achieved, where 3 tonnes of poultry manure was applied along with recommended dose of chemical fertilizer [69]. The height of plant, number of compound leaves per hill, number of haulms per hill, yield attributes and yield were greatly influenced by integrated nutrient management (INM). He further observed that application of 150:100:120 kg NPK, 20 t FYM, 5 t vermicompost and 3 t Neem cake/ha brought par amount of improvement in growth and tuber yield of potato [70].

Application of 75% of full recommended doses of fertilizers (RDF)(120:75:75 NPK/ha)+ 8t vermicompost +pre-sowing tuber treatment with Azotobacter and PSB proved significantly superior in terms of number of tubers per hills, harvest index, tuber yield (32.7 t/ha) and benefit cost ratio (1.75) of potato over rest of the treatments [71]. Application of225kg N+ 150 Kg P2O5 + 225 Kg K2O + 40 Kg S + 2 Kg B + 6 kg ZnSO4/ha not only enhanced the potato tuber yield but also had pronounced effect on tuber dry matter yield [72].

Afertilizer dose of 150: 80: 100 Kg N, P2O5 and K2O per hectare along with FYM @ 10 t ha-1 and a spacing of 60 cm x 20 cm is recommended to produce a profitable potato crop in coastal agro-climatic condition [73]. Application of combined nutrient management is the best combination for sustainable crop yield [74].

Conclusion

Low soil fertility is one of the contributing factors to low potato yield in most parts of world. Among the plant nutrients, plant requires a variety of elements for growth and development of which N,P,K are the most important elements. If due attention will pay to nutrient management then potato yield of our country can be increase by 50%. However, for maximization of productivity as well as to maintain the soil fertility adoption of integrated nutrient management is the right solution.

Application of review: Effect of NPK on growth and yield of Potato

Review Category: Fertilizer, Nutrient Management

Abbreviations:

K_2O: Potassium oxide

P_2O_5: Phosphorus pentoxide

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