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Research Article

Multisource Nutrient Application in Potato for High Grade Tuber Production

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Abstract

Tuberization of potato is function of nutrient application and sources of nutrients. Judicious use of chemical fertilizers in combination with PSB (Phosphate Solubilizing Bacteria), VAM (Vesicular Arbuscular Mycorrhizal) Fungi, *Azotobacter* and/or mustard cake is beneficial for high grade tuber production in potato and dry matter production. The increase in number of tubers under different treatments was result of efficient utilization of nutrients by the plant under the influences of microbial activity of biofertilizers. The correlation and regression had confirmed positive correlation (r^2 = 0.351 and 0.865) of dry matter content (%) over average weight (g) and specific gravity of tubers, respectively. The dry matter production of potato tuber was directly influenced by specific gravity.

Keywords: Azotobacter; Potato; PSB; Specific Gravity; Tuberization; VAM

Introduction

Potato (*Solanum tuberosum* L.) is adopted to diverse climatic conditions viz. tropical, subtropical and temperate and grown for production of vegetables or true potato seeds. The dry matter and protein production in unit area is higher than common cereals so potato is considered as staple crop in many parts of world. Due to high nutritional and energy value of potato tuber and very high economic outputs potato is most suitable crop for developing countries [1,2]. Potatoes also have some medicinal value beside economical and nutritious food source [3].

Tuber is modified stem and economic part of potato. A potato tuber contains about 80% water and rest as dry matter. Starch accumulates about 70% of total solids [4]. It has very high capacity of dry matter production (47.6 Kg/hectare/day). Average composition of potato tuber is: dry matter (20%), starch (13 - 16%), total sugar (0 - 2%), protein (2%), fibre (0.5%), lipids (0.1%), vitamin C (31 mg/100g fresh weight), ash (1 - 1.5%) and vitamin A and minerals in trace. It is low energy food (97 Kcal/100g fresh weight) [4].

Tuberization in potato is function of nutrient uptake and utilization by plants. Fertilizer scheduling in terms of dose, time and sources of nutrients is determining factor for potato tuber formation and development. Effective nutrient scheduling ensures better emergence and survival of plants, stimulates vegetative growth and branching, improves photosynthetic activities, increases tuber yield and income to farmers [5]. Balanced fertilization of potato plants is essential to improve nutritional value and tuber quality. Availability of nutrients from multiple sources ensures effective nutrient utilization in comparison to single source thus, application of inorganic fertilizers in combination with vermicompost and biofertilizers has been reported for economic and quality potato production [6]. Application of *Azotobacter* and phosphobacteria (PSB) as nutrient source is important to obtain optimum productivity [7]. Bio- fertilizer is a preparation which contains living cells of various microbes that have the ability to make the nutrients available to the plant through solubilisation of unavailable nutrient like phosphorus or fixation of atmospheric minerals like nitrogen. Lallawmkima., *et al.* [5] has also advocated for replacement of 50% of RDF (Recommended Dose of Fertilizers) by biofertilizers like VAM, PSB and *Azotobacter* without impairing productivity and profitability. The current research has emphasized over application of biofertilizers in combination to inorganic sources to obtain high grade potato tubers.

Materials and Methods

The investigation was carried out at research farm of Lovely Professional University, Punjab, by using following treatments: T_1 (100% RDF), T_2 (Half of RDF with PSB and VAM), T_3 (Half of RDF with PSB and Mustard cake), T_4 (Half of RDF with PSB and *Azotobacter*), T_5 (T_2 + Mustard cake), T_6 (T4 + VAM), T_7 (T_3 + *Azotobacter*) and T_8 (T_7 + VAM). Potato tubers of Kufri Jyoti variety having 30 - 40g weight and uniform size were kept in shade for sprouting and sprouted tubers were planted at spacing of 25 cm x 60 cm on ridges. Planting was done in last week of October.

Development study of different plants parts during the growth period helped to explain the effect of various treatments on the final yield. The number of tubers from five randomly selected plants was counted and recorded. The average fresh weight of each tuber and the tuber of each plant was measured in gram from each tagged plant. The average marketable weight of the tuber was also measured in gram from different plants after 15 days of shade dry. Dry matter contents of shoot, root and potato tubers were determined by the percentage weight of various plant parts obtained after oven drying (at 70^0C) till the constant weight is obtained [8]. Data was analysed by using OPSTAT and XLSTAT online software.

Results and Discussion

Average number of tubers per plant

The data pertaining to average number of tubers per plant, presented in table 1, confirms the non-significant effect of biofertilizers i.e. PSB in combination with *Azotobacter*, VAM or mustard cake on number of tubers developed in each plant. However, the highest number of tubers per plant (10) has been reported in T_6 followed by 9.67 in T8 and 9.33 in T_5 in comparison to 8.17 in T_1. The increase in number of tubers under different treatments might be result of efficient utilization of nutrients by the plant under the influences of microbial activity of biofertilizers. Highest number of potato tubers per plant had also been reported by Mohammadi., *et al.* [9] who had reported that integrated application of urea with nitrogen which contain *Azotobacter* and *Azospirillum* as active component had significantly affected number of tubers but there was no significant effect when they applied alone. Dash and Jena [10] has also reported highest number of tubers per plant when 100% recommended dose of NP was combined with soaking of tuber in urea and NaHCO3 along with application of *Azotobacter* and PSB. Yao., *et al*. [11] had reported significant effect of inoculation of micro propagated potato Gold rush with Glomus species on number of tubers per plant.

Treatments	Average No of Tubers Per Plant	Average Weight of Tuber (g)	Average Fresh Weight (g) of Tubers Per Plant	Average Marketable Weight (g) of Tubers Per Plant
T_1	8.17	42.20	339.97	306.10
T_2	8.23	55.05	453.69	420.13
T_3	8.0	48.81	390.17	360.99
T_4	8.0	47.58	377.56	353.69
T_5	9.33	49.61	464.70	428.58
T_6	10.00	53.76	538.15	502.76
T_7	8.63	52.26	449.74	417.37
T_8	9.67	49.29	442.50	506.79
Mean	8.75	50.70	445.05	412.30
CD at 5%	NS	4.99	93.06	81.5
SEm ±	1.12	8.130	2824.40	2165.95
CV	12.09	5.62	11.94	11.29

Table 1: Effect of biofertilizers application on number and average weight of tubers.

Average weight of tubers

It is evident from table 1 that average weight of individual tuber and fresh and marketable weight of tubers per plant were significantly affected by application of *Azotobacter*, VAM or mustard cake in combination with PSB and 50% NPK from RDF. The highest average weight of tuber (53.76g), average fresh weight of tuber per plant (538.15g) and average marketable weight of tubers per plant (502.76g) were reported in T_6 followed by T_5 (49.61g, 464.70g and 428.58g respectively) and T_2 (55.05g, 453.69g and 420.13g respectively) whereas the lowest value (42.20g, 339.97g and 306.10g respectively) were recorded in T_1 (100% RDF). Thus, all the treatments have been reported to improve average weight of tubers in comparison to the only inorganic fertilizer as a source of nutrients.

The increase in average and marketable weight of potato tubers in these treatments might be due to better supply of nutrients, better root development secretion of phytohormone and improve uptake of nitrogen and phosphorous in presences of PSB and other biofertilizers as confirmed by Dash and Jena [10]. Similar finding has also been reported by Kumar., *et al* [12]. Hussain., *et al.* [13] had also recorded improvement in tuber yield by 10.04% to 18.31% due to application of *Azotobacter* inoculation along with recommended dose of fertilizer. Yao., *et al.* [11] had also reported significant effect of inoculation of micro propagated potato cultivar LP89221 with Glomus species on fresh weight of tuber per plant. Singh., *et al.* [14] had also reported improvement in yield of *Amorphophallus corm* due to combined application of Vermicompost, mustard cake and urea.

Dry matter content of different parts of plant

The data pertaining to dry matter content of tubers, shoots and roots has been presented in table 2. It is evident from table that dry matter content in tubers and shoots were significant but roots of potato plant did not show significant variation. The maximum percentage (21.76%) of dry matter in Tubers was found in T_8 followed by T_6, T_5 and T_2 (20.60%, 19.26% and 17.91% respectively). However, minimum percentage (13.05%) of dry matter in tubers was found in T_1 (100% RDF). The highest (21.29%) dry matter percentage in shoots was found in T6 followed by T_8, T_5 and T_7 (21.05%, 19.84% and 19.66% respectively) whereas the lowest percentage (16.52%) was found in T_1 (100% RDF). The maximum percentage (20.00%) of dry matter in root was found in T_7 followed by T_6, T_2 and T_3 (19.54%, 18.77% and 17.89% respectively) and lowest percentage was again found in T_1 (14.13%). The high value of dry matter content in potato plants might be result of efficient utilization of nutrients by plants for synthesis of organic substrates like carbohydrates, proteins etc which are responsible to add dry matter in various plant parts. The present finding is in conformity with the finding of Jatav., *et al*. [15] who proposed that integrated use of 50% PK from inorganic fertilizers along with RDF of N resulted in the highest dry matter yield of potato (5.72 tonnes/ha).

Correlation study between dry matter content and average weight of tubers

The correlation and regression study between dry matter content (%) and average weight of tubers (g) confirmed a positive correlation (r^2 = 0.351) between the two variants with positive slope of regression line (Figure 1). However, the result was reported to be non-significant. This confirms that the average weight of tubers may not be contributing factor for dry matter production of potato tubers under various treatments.

Treatments	Dry Matter (%) in Tubers	Dry Matter (%) in Shoots	Dry Matter (%) in Roots
T_1	13.05	16.52	14.13
T_2	17.91	19.62	18.77
T_3	14.19	17.79	17.89
T_4	15.37	18.75	16.68
T_5	19.26	19.84	15.98
T_6	20.60	21.29	19.54
T_7	16.61	19.66	20.00
T_8	21.76	21.05	15.49
Mean	17.34	19.31	17.31
CD at 5%	0. 959	2.085	NS
SEm ±	0.300	1.417	6.100
CV	3.16	6.16	14.27

Table 2: Effect of biofertilizers application on dry matter content of plant parts.

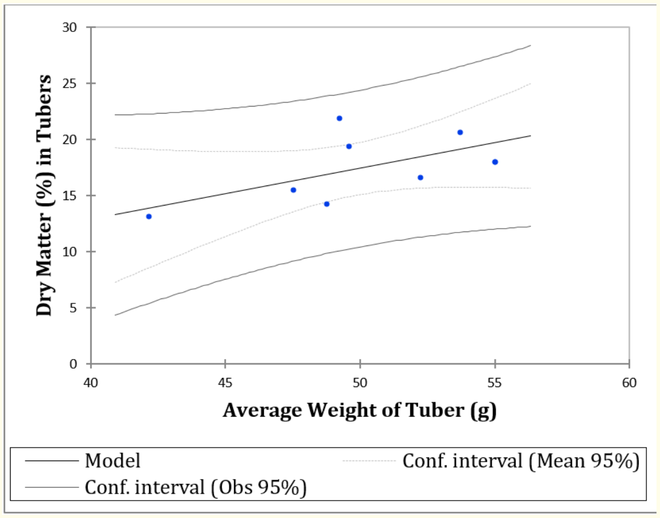

Figure 1: Regression of dry matter (%) in tubers by average weight of tuber (g) (r^2 = 0.351).

Analysis of variance (Dry Matter (%) in Tubers)					
Source	**DF**	**Sum of squares**	**Mean squares**	**F**	**Pr > F**
Dry Matter	1	23.493	23.493	3.246	0.122
Error	6	43.422	7.237		
Corrected Total	7	66.916			

Equation of Dry Matter (%) in Tubers

Dry Matter (%) in Tubers = 0.455*Average Weight of Tuber (g) -5.347

Correlation study between dry matter percent and specific gravity of tubers

The correlation and regression study of dry matter (%) content in tubers and specific gravity of tubers reflects very high correlation value ($r^2 = 0.865$) (Figure 2). Thus, 86% of the variability of the Dry Matter (%) in Tubers is described by the specific gravity. The ANOVA table confirms smaller p-value at 5% level of significance, thus the specific gravity of each treatment contributes significantly towards dry matter content (%) of tubers in comparison to mean value.

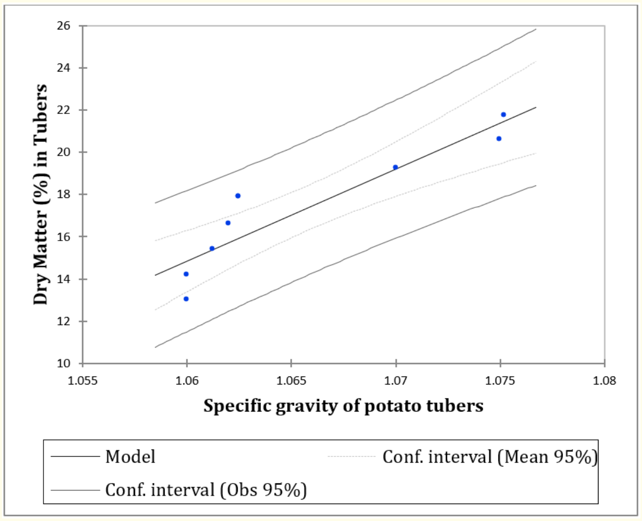

Figure 2: Regression of dry matter (%) in tubers by specific gravity of potato tubers ($r^2 = 0.865$).

Analysis of variance (Dry Matter (%) in Tubers)					
Source	**DF**	**Sum of squares**	**Mean squares**	**F**	**Pr > F**
Dry Matter	1	57.864	57.864	38.358	0.001
Error	6	9.051	1.509		
Corrected Total	7	66.916			

Equation of Dry Matter (%) in Tubers:

Dry Matter (%) in Tubers = 436.01*Specific gravity of potato tubers -447.33

Conclusion

The investigation confirmed the contribution of biofertilizer sources of nutrients in average weight and dry matter production in potato. PSB in combination with *Azotobacter*, VAM or mustard cake has improved number of tubers developed in each plant, average weight of tubers and dry matter content of different parts of plant. Replacement of fifty percent of inorganic fertilizers by VAM or *Azotobacter* or mustard cake in combination with PSB as economical tuber production in potato. Further, a strong correlation ($r^2 = 0.865$) was established between dry matter production and specific gravity of potato tubers. Among various treatments T_6 (Half of RDF + PSB + *Azotobacter* + VAM), T_7 (Half of RDF + PSB + Mustard cake + *Azotobacter*) and T_8 (Half of RDF + PSB + Mustard cake + *Azotobacter* + VAM) were reported to be most effective treatments.

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