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Effect of integration of nutrient sources on yield and quality of potato under rainfed conditions

S.K. Yadav*, A.K. Srivastava and T.K. Bag
ICAR-Central Potato Research Station, Shillong 793 009, Meghalaya

ABSTRACT

The effect of integration of nutrient sources on potato tuber yield and quality was investigated during three consecutive years (2011-2013) at Central Potato Research Station, Shillong, Meghalaya. The trial was laid out in randomized block design, replicated thrice, with 8 treatments, *viz*., control (no nutrients application); 100% recommended dose of mineral fertilizers (RDF); 75% RDF + 25% Nitrogen (N) through farm yard manure (N-FYM); 50% RDF + 50% N-FYM; 75% RDF and tuber inoculation with biofertilizers [*Azotobacter* (Azot) + phosphate solubilizing bacteria (PSB)]; 75% RDF and 25% N-FYM + inoculation with biofertilizers (Azot + PSB); 50% RDF + 50% N-FYM + inoculation with biofertilizers (Azot + PSB) and 100% N-FYM. The integration of 75% recommended dose of fertilizers through synthetic sources and 25% recommended dose of nitrogen through farm yard manure (FYM) alongwith inoculation of biofertilizers (*Azotobacter* and phosphate solubilizing bacteria) brought about the significant improvement in plant population, yield attributes, total yield, desirable grade wise tuber size distribution and quality parameters in potato especially nitrogen concentration and discarded tuber proportion. Marketable and total tuber yields were significantly reduced due to production of higher proportion of total weight of discarded tubers with the application of 100% recommended dose of fertilizers through FYM on nitrogen basis. Both biofertilizers played significant role in supplementing the nutrient needs of potato through augmenting the availability nitrogen and phosphorus. The incidence of late blight was higher with application of synthetic fertilizers, whereas scabbed and discarded tubers were more with sole application of FYM.

Key words: Integrated nutrient management, nutrient, potato, tuber yield.

INTRODUCTION

Potato is an important horticultural crop in North Eastern hill region of India. Where productivity is very low (10.9 t/ha) as compared to national average of 22.7 t/ha (Anon, 1). The prolonged and over usages of synthetic fertilizers have resulted in human and soil health hazards along with threat environmental pollution. However, the integrated use of synthetic fertilizers along with various organic sources is capable of sustaining higher crop productivity, improving soil quality and productivity on long term basis (Kumar *et al*., 7). Biofertilizers have shown good promise and have emerged as an important component of integrated nutrient supply through playing a very significant role for improving crop growth and quality of produce (Baskaran *et al*., 2). *Azotobacter* is a nitrogen fixing bacterium, which facilitates steady supply of nitrogen during plant growth. Phosphate solubilizing bacteria has direct effect on mobilization of phosphorus in soil through solubilization, which in turn help the plant to grow better. Field studies conducted under north eastern hill region on role of biofertilizers (*Azotobacter* and phosphate solubilizing bacteria) on nitrogen and phosphorus economy revealed that their use improved the productivity of the crop and nutrient uptake as well found also cost-effective due to low input cost and renewable sources of plant nutrients to supplement the parts of synthetic fertilizers (Yadav *et al*., 13). A judicious use of inorganic fertilizers, organic manures and biofertilizers may be effective not only in sustaining crop productivity and soil health, but also a viable, economic and environment-friendly alternative to supplement synthetic fertilizers to the crops. Hence, a field experiment was undertaken to study the effect of integrated nutrient management on yield and quality of potato under rainfed conditions.

MATERIALS AND METHODS

A fixed plot field experiment was conducted during summer season of three consecutive years from 2011 to 2013 at Central Potato Research Station, Shillong, Meghalaya. The geographical co-ordinates of experimental field were 25°54' N latitude and 91°84' E longitude and an altitude of 1,738 m above mean sea level. The soil was sandy loam in the texture with pH 5.12, being high in organic carbon (1.88%), medium in available nitrogen (304.5 kg/ha), low in available phosphorus (14.2 kg/ha) and high in available potassium (297.0 kg/ha). The trial was laid

*Corresponding author's E-mail: sanjaybhu05@rediffmail.com

out in randomized block design, replicated thrice, with 8 treatments, *viz*., control (no nutrients application); 100% recommended dose of mineral fertilizers (RDF); 75% RDF + 25% nitrogen (N) through farmyard manure (FYM); 50% RDF + 50% N-FYM; 75% RDF and tuber inoculation with biofertilizers [*Azotobacter* (Azot) + phosphate solubilizing bacteria (PSB)]; 75% RDF and 25% N-FYM + inoculation with biofertilizers (Azot + PSB); 50% RDF + 50% N-FYM + inoculation with biofertilizers (Azot + PSB) and 100% N-FYM. Potato cultivar 'Kufri Jyoti, is a widely adapted medium maturing variety was planted during first week of March in the net plot of 4 m × 4.8 m with spacing of 60 cm × 20 cm. Well-decomposed farm yard manure (0.53% N, 0.29% P and 0.61% K) collected from a nearby farm was applied into the plots as per the treatments. The recommended dose of N, $P_20_{5,}$ and K_2O was taken as 140, 120 and 60 kg/ha for potato. Nitrogen, phosphorus and potassium were applied in the form of urea, single super phosphate and muriate of potash, respectively. Half of N and whole of phosphate and potash were applied at planting of the crop. The remaining half of the nitrogen was applied as top dressing at the time of earthing up according to treatment. Recommended package and practices for disease and insect management for potato crop were followed. Two solutions of biofertilizers (*Azotobacter* and PSB) were prepared by 250 g making suspension with of each biofertilizer in 40 l of water separately. Jaggery (molasses) slurry use for adhesiveness was prepared by boiling 2 kg jaggery per litre of water. After cooling, one liter of jaggery slurry was added to each solution of biofertilizers. Then potato seed tubers were dipped in the biofertilizer solution for 30 min. as per the treatment and dried in shade. The treated tubers were planted at 20 cm apart in the furrows at 60 cm distance and covered immediately after planting. The earthing up was done at 45 days after planting.

Plants samples were selected randomly to determine plant height, number of shoots and leaves per plant at peak growth stage (70-75 DAP). For recording growth attributes of potato, five hills in the net plot area were randomly selected and tagged. Ten plants were randomly selected from tagged plants and the height was measured from the neck node to the tip of the upper most leaves and average length was recorded. However, for the yield attributes characters, three hills were randomly selected from the sample rows (border rows) at crop maturity stages. Three tagged plants were harvested from the earmarked area outside the net plot and brought to the laboratory. The plants were separated into tubers, green leaves and haulms and their dry weights recorded after drying in a hot air oven at 75^0C till constant weights were obtained. All the plants from net plot area were harvested manually at maturity. All the tubers were dried and graded in shade and their weight and number were recorded. The tuber yield of different plots were estimated and converted into tonnes per hectare. All observations for each character were subjected to statistical analysis according to the standard method (Panse and Sukhatme, 9). The calculated values of the treatments and error variance ratio were compared with Fisher and Yate's F table at 5% level of significance. The differences between significant treatment means were tested.

RESULTS AND DISCUSSION

The growth attributes of potato were recorded during the maximum vegetative growth stage in all the three years of experiment (Table 1). The

Table 1. Treatment effects on growth attributes of potato at peak growth stage.

Treatment	Plant height (cm)				No. of shoots/ plant				No. of leaves/ plant			
	2011	2012	2013	Mean	2011	2012	2013	Mean	2011	2012	2013	Mean
Control	26.7	25.5	26.3	26.2	2.87	2.43	2.67	2.66	30.0	26.0	28.8	28.3
100% (RDF)	39.7	35.4	34.2	36.4	3.60	3.20	3.53	3.44	39.7	38.3	40.7	39.6
75% RDF and 25% N-FYM	37.3	34.7	34.4	35.5	3.80	3.23	3.43	3.49	39.3	34.7	40.3	38.1
50% RDF and 50% N-FYM	36.3	35.2	33.3	35.0	3.48	3.13	3.00	3.20	37.7	34.3	37.3	36.4
75% RDF and (Azot + PSB)	34.0	34.8	34.6	34.4	3.60	2.97	3.50	3.36	37.0	29.3	36.7	34.3
75% RDF and 25% N-FYM + (Azot + PSB)	38.0	35.7	35.2	36.3	3.87	3.30	3.87	3.68	39.4	38.7	40.9	39.7
50% RDF and 50% N-FYM + (Azot + PSB)	36.0	34.3	34.3	34.9	3.57	3.17	3.30	3.34	38.7	35.3	37.0	37.0
100% N-FYM	35.7	34.0	34.3	34.7	3.47	3.07	3.20	3.24	37.7	29.0	38.3	35.0
$CD_{0.05}$	3.77	4.23	4.38	4.13	0.49	0.43	0.41	0.44	3.07	3.03	3.10	3.07

highest improvement in all growth attributes were observed with integration of 75% RDF + 25% N-FYM in combination with biofertilizers, which was similar to all treatments except control. The prominent variation among growth attributes was shown higher for number of leaves per plant than plant height and number of shoots due to different treatments. The lowest value of growth attributes was obtained under control plot (no nutrient application). The application of 75% RDF along with biofertilizers as well as 100% N-FYM has no response up to that level to enhance the growth attributes similar to other treatments, where FYM integrated with RDF to meet the proportional remaining RDF requirement. The results indicated that potato crop required high amount of nutrients for its proper growth and 100% replacement of nitrogen through organic sources (FYM) was incapable to contribute plant nutrients adequately during its growth period. It might be due to slow mineralization rate of organic matter under low temperature prevailing in hill regions at initial crop growth stages. Integration of nutrient sources influenced the growth attributes especially number and size of leaves by supplementing the nutrient requirement at constant level throughout the plant growth stage. These findings are in agreement with those of Choudhary *et al.* (3). Leaves of potato were major factor for nutrient assimilation and translocation of photosynthetic product into potato tubers for fast bulking during peak growth stage under field conditions. The 75% RDF through inorganic fertilizers application at the time of planting resulted in improvement of growth attributes during early growth phase, while in later stage nutrient requirement of crop supplemented by release of nutrients from FYM after mineralization and biofertilizers. The integration of FYM also improved the efficiency of inorganic fertilizers by improving the physical condition of the soil (Yadav *et al*., 12).

Yield attributes are one of the most important factors for evaluating potato productivity under field condition is presented in Table 2. Generally yield is the multiplication of number of tubers and its respective weight per unit area. The highest number of tubers and weight per plant were recorded with the application of 75% RDF + 25% N-FYM with inoculation of biofertilizers, which is significantly higher than 75% RDF with inoculation of biofertilizers and control plot but remains at par to the rest of the treatments under investigation during all the three years. It is also clear from the analyses of data that the lower number of tubers was recorded during the second year compared to the first and third years of experiment due to late onset of rainfall. The number of tubers as not much affected than weight of tuber per plant due to integration of nutrient sources and biofertilizers during all the years of investigation. The treatment receiving 100% N-FYM recorded almost similar number of tubers but lower weight per plant as compared to other treatment except control. The variation of tuber number was less in all treatments except control due to genetic potential of the crop but amount of assimilates translocation in final tubers associated with integration of nutrient sources during study. The highest weight of tubers per plant directly associated with growth attributes of potato. Therefore, application 75% RDF + 25% N-FYM along with inoculation of biofertilizers might have enhanced the photosynthesis of crop by improving the desired growth attributes like number of leaves with good canopy during the entire growth phase resulted more bulking in integrated treatment as compared to control plot (Sood, 11).

Data on marketable and total tuber yield of potato under different treatments are presented in Table 3. Marketable and total tuber yield were significantly higher with integration of nutrient sources either with

Table 2. Treatment effects on yield attributes of potato.

Treatment	Nos. of tubers /plant				Weight of tubers /plant (g)			
	2011	2012	2013	Mean	2011	2012	2013	Mean
Control	6.5	5.8	6.5	6.3	173.3	161.7	176.0	170.3
100% RDF	8.4	7.1	8.3	7.9	207.3	201.7	208.7	205.9
75% RDF and 25% N-FYM	8.3	7.7	8.2	8.0	221.3	216.0	235.0	224.1
50% RDF and 50% N-FYM	7.8	7.7	8.6	8.0	226.0	220.3	230.0	225.4
75% RDF and (Azot + PSB)	7.4	6.6	7.7	7.2	186.3	181.0	192.0	186.4
75% RDF and 25% N-FYM + (Azot + PSB)	8.6	8.3	8.6	8.5	239.3	234.0	244.7	239.3
50% RDF and 50% N-FYM + (Azo + PSB)	8.5	8.1	8.5	8.4	235.3	229.3	236.7	233.8
100% N-FYM	8.1	7.9	8.6	8.2	212.0	210.3	214.3	212.2
$CD_{0.05}$	0.91	0.98	0.94	0.94	28.16	25.34	29.14	27.55

Table 3. Treatment effect on marketable and total tuber yield.

Treatment	Marketable tuber yield				Total tuber yield (t/ha)			
	2011	2012	2013	Mean	2011	2012	2013	Mean
Control	5.6	4.8	5.4	5.3	7.9	6.7	8.4	7.7
100% (RDF)	13.5	12.3	14.7	13.5	16.4	15.4	17.8	16.5
75% RDF and 25% N-FYM	12.9	10.7	14.5	12.7	16.6	13.8	17.9	16.1
50% RDF and 50% N-FYM	12.9	9.8	14.7	12.5	16.3	12.8	17.9	15.7
75% RDF and (Azot + PSB)	11.6	8.3	13.1	11.0	13.9	10.6	16.1	13.5
75% RDF and 25% N-FYM + (Azot + PSB)	16.9	12.8	15.8	15.2	18.7	15.6	18.8	17.7
50% RDF and 50% N-FYM + (Azot + PSB)	14.9	10.6	14.6	13.4	17.8	14.1	17.4	16.4
100% N-FYM	8.87	6.62	11.9	9.1	13.8	10.1	16.4	13.4
$CD_{0.05}$	1.28	1.31	1.34	1.31	1.29	1.33	1.36	1.33

inoculation of biofertilizers or without biofertilizers over control. Highest total and marketable tuber yield were recorded by application of 75% RDF and 25% N-FYM + inoculation with biofertilizers (*Azotobacter* + PSB), which was significantly higher than the rest of the treatments. Integration of 75% RDF and 25% N-FYM + inoculation with biofertilizers (*Azotobacter* + PSB) was better performing in terms of tuber yield than 75% RDF and 25% N-FYM due to additional inoculation of biofertilizers (*Azotobacter* and PSB). Yield of potato is product of number of tubers and their respective weight per plant per unit area. Integration of 75% RDF + 25% N-FYM along with inoculation of biofertilizers resulted in higher number of tubers accompanied by the highest weight of tubers per plant, consequently, the yield of both marketable and total tuber yield were noticed higher under the study. The result shows that supply of 100% N-FYM alone was not much helpful in producing higher tuber yield under this situation. Slow mineralization of plant nutrients from organic matter under low temperature condition prevailing in the north eastern hill region might be responsible for its inability to produce high tuber yields due to inadequate crop nutrition (Kumar *et al*., 6). The gap between marketable and total tuber yields was greater (32.1%) by supplying of 100% N-FYM. In contrast, inoculation of biofertilizers narrowed (12.8%) the gap between two parameters. The greater effect of use of both biofertilizers (*Azotobacter* and PSB) treatment along with integrated use of 75% RDF through mineral fertilizers and 25% N-FYM and inoculation of biofertilizers might be due to higher N fixation through *Azotobacter* in addition to enhanced rate of P availability in rhizosphere by PSB resulting in higher growth of the crop as reflected by increased growth and yield attributes throughout the growth period that ultimately led to higher tuber yield. The 75% RDF with biofertilizer treatments without manures showed very poor performance on tuber productivity of potato under the study. The results showed that biofertilizer required organic sources of nutrient (heterotrophic) for its early establishment, necessary for exerting beneficial effect on tuber productivity. The results corroborate the findings of Yadav *et al*. (14).

Different quality parameters were observed at the time of harvest of potato tubers under field condition is presented in Table 4. The proportion of green tubers were higher with application of 100% RDF as compared to 100% N-FYM. The percentage of blighted tubers were higher with application of 100% RDF through mineral fertilizers compared to application 100% N-FYM on nitrogen basis. While the scabbed damage tubers were found to be more when of 100% FYM was applied. The proportion of scabbed tubers as gradually increased according to increase in the contribution of RDF through FYM on nitrogen basis. More discarded tubers were found with the application of 100% N-FYM than 100% mineral RDF. No significant differences were found for discarded tubers with inoculation of biofertilizers with integration of similar quantity of FYM in the ratio of either 75:25 or 50:50 during all the years of experiment. The proportions of green tubers were higher with application of 100% RDF through synthetic fertilizers due to more exposure of tubers to sunlight. This might be due to the rate of infiltration of rainwater was lower resulted higher runoff caused to erosion of soil from the ridges under application of synthetic fertilizers. Whereas incorporation of FYM and biofertilizers increased the capillary pore as well as binding capacity of soil by modification of soil physical environment, which reduces the losses of soil through erosion and protect the tubers from sun exposure. Bio-fertilizers especially *Azotobacter* also produced polysaccharides, which improve soil

Table 4. Treatment effects on tuber quality (% of total weight of tubers).

Treatment	Green	Blighted	Scabbed	Discarded
Control	0.95	1.12	0.76	31.0
100% recommended dose of fertilizers (RDF)	2.27	1.54	0.71	18.6
75% RDF and 25% N-FYM	1.24	1.35	0.93	21.0
50% RDF and 50% N-FYM	1.13	1.23	1.23	20.6
75% RDF and (Azot + PSB)	1.57	1.40	0.75	18.4
75% RDF and 25% N-FYM+ (Azot + PSB)	1.19	1.22	0.95	13.1
50% RDF and 50% N-FYM + (Azot + PSB)	1.04	1.19	1.18	19.7
100% N-FYM	0.87	0.95	1.86	32.5
$CD_{0.05}$	0.18	0.19	0.16	3.20

aggregation (Gaur, 4). The late blight proceeds toward the plant tubers through the foliage of potato. More succulent foliage with application of 100% RDF through synthetic fertilizers was the major cause of blighted tubers than 100% N-FYM. Similar results also reported that high mineral fertilizers increase foliar blight severity (Lambart *et al*., 8; Ros *et al*., 10). In contrast of mineral fertilizers, scabbed damaged and discarded tubers were more under application of 100% N-FYM. The pathogen of scab disease might be either aerobic or heterotypic in nature resulted more growth under FYM application treatment. This finding confirms previous studies, which showed that scab damage increases when organic fertilizers were applied to potato crop (Huber and Watson, 5). Discarded tubers were found also more due to poor nutrition through FYM application.

Based on results it may be concluded that application of 75% recommended dose of fertilizers through mineral sources and 25% recommended dose of nitrogen substituted through FYM along with inoculation of biofertilizers (*Azotobacter* and phosphate solubilizing bacteria) brought about the significant improvement in yield attributes, total yield and quality parameters of potato in the rainfed conditions of north eastern hill region.

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