INTRODUCTION

Fertility is one of the controllable major factors that affects the yield and quality of potatoes. Different rates of NPK fertilization lead to differences in tuber yield and chemical composition at harvest and affect the behaviour of stored potato (7). Besides tuber yield, tuber size distribution is very important to the producer and the processor, as processing of large size tuber results in higher percentage of finished product recovery and lower peeling losses. There are reports that P increases the yield of large tubers (1). It is also documented that P increases the dry matter content of potato as it is the constituent of potato starch. The application of P exerts considerable influence over cultivars of potato. The varieties accounted for about 35% variation in P dose requirement (5). Therefore, the present study was undertaken to: (i) optimize the P requirement of newly released Chipsona varieties for higher processing-grade tuber yield, and (ii) study the effect of rate of P and cultivar on processing quality at harvest and during storage.

MATERIALS AND METHODS

Field experiments were conducted during autumn seasons of 2000-2002 at Central Potato Research Institute Campus, Modipuram (29° 4’ N, 77° 46’ E, 237 m amsl) in a split plot design with three replications. The treatments comprised five levels of phosphorus (0, 40, 80, 120 and 160 kg ha⁻¹) in sub-plots, and two varieties (Kufri Chipsona-1 and Kufri Chipsona-2) in main plots. The soil was sandy loam with neutral pH (7.1), low in organic carbon (0.28%) and available nitrogen (152 kg ha⁻¹), high in available phosphorus (37 kg ha⁻¹) and medium in available potassium (138 kg ha⁻¹). Uniform dose of 240 kg N and 140 kg K₂O ha⁻¹ was applied (9). Half dose of N, full amount of K and P (as per treatments) were applied at the time of planting, and the remaining half N at the time of earthing up (i.e. 20-25 days after planting). The crop was dehaulked at 110 days and harvested two weeks later. Observations on growth and yield attributes were recorded, and grading of the tubers was done manually. Tubers of more than 45 mm size were considered as processing grade tubers.

Biomass yield was worked out by adding the weight of fresh vines at the time of harvest with the tuber yield. The harvest index was calculated by dividing the tuber yield by
biomass yield. Dry matter content of the tubers was determined by oven drying method (8), while specific gravity was measured by hydrometer. Reducing sugars were estimated at the time of harvesting following the standard procedure (10). Chip colour was scored on a scale of 1-10 subjectively, where 1 is considered white and 10 as dark brown (2). A sample of 30 tubers from each treatment was also stored at 10-12°C with CIPC (isopropyl N-(3-chlorophenyl) carbamate) fogging (a sprout inhibitor) to investigate the effect of P on chip colour during storage. The data were analyzed using software IRRISTAT.

RESULTS AND DISCUSSION

Growth and yield attributes: Response to P application was positive with regard to growth traits recorded viz., stem number/m, plant height and leaf number/plant. However, the statistically significant increase in above stated parameters was observed only up to 80 kg P\textsubscript{2}O\textsubscript{5}/ha (Table 1). Limited response to P fertilization can be ascribed to the fact that experimental soils were rich in available phosphorus. Grewal and Sud (4) also reported that optimum dose of phosphorus for potato was 90 kg P\textsubscript{2}O\textsubscript{5}/ha.

Table 1. Effect of phosphorus rate on growth, yield attributes, yield and economics of processing cultivars (average over 2 years)

<table>
<thead>
<tr>
<th>Phosphorus (P\textsubscript{2}O\textsubscript{5} kg ha\textsuperscript{-1})</th>
<th>Stem number/m</th>
<th>Plant height (cm)</th>
<th>Leaf number/plant</th>
<th>Tuber number (thousand/ha)</th>
<th>Tuber yield (q/ha)</th>
<th>Biomass yield (q/ha)</th>
<th>PUE**</th>
<th>Net returns (Rs./ha)</th>
<th>B.C ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>26.8</td>
<td>73.1</td>
<td>92.0</td>
<td>342.8</td>
<td>598.4</td>
<td>289.4</td>
<td>353.7</td>
<td>433.3</td>
<td>-</td>
</tr>
<tr>
<td>40</td>
<td>27.7</td>
<td>75.1</td>
<td>95.1</td>
<td>351.1</td>
<td>611.0</td>
<td>290.4</td>
<td>360.7</td>
<td>442.8</td>
<td>0.18</td>
</tr>
<tr>
<td>80</td>
<td>30.7</td>
<td>77.9</td>
<td>102.4</td>
<td>372.4</td>
<td>669.4</td>
<td>311.7</td>
<td>386.6</td>
<td>484.1</td>
<td>0.41</td>
</tr>
<tr>
<td>120</td>
<td>30.4</td>
<td>75.7</td>
<td>100.9</td>
<td>353.2</td>
<td>641.7</td>
<td>302.7</td>
<td>370.6</td>
<td>459.7</td>
<td>0.14</td>
</tr>
<tr>
<td>160</td>
<td>30.0</td>
<td>77.2</td>
<td>96.9</td>
<td>379.1</td>
<td>656.5</td>
<td>313.7</td>
<td>382.1</td>
<td>492.2</td>
<td>0.18</td>
</tr>
<tr>
<td>CD (P&lt;sub&gt;0.05&lt;/sub&gt;)</td>
<td>2.8</td>
<td>3.8</td>
<td>8.9</td>
<td>29.9</td>
<td>58.3</td>
<td>16.1</td>
<td>16.2</td>
<td>23.1</td>
<td>-</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variety</th>
<th>Stem number/m</th>
<th>Plant height (cm)</th>
<th>Leaf number/plant</th>
<th>Tuber number (thousand/ha)</th>
<th>Tuber yield (q/ha)</th>
<th>Biomass yield (q/ha)</th>
<th>PUE**</th>
<th>Net returns (Rs./ha)</th>
<th>B.C ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kufri Chipsona-1</td>
<td>25.9</td>
<td>64.7</td>
<td>91.0</td>
<td>374.5</td>
<td>682.7</td>
<td>295.7</td>
<td>382.9</td>
<td>476.0</td>
<td>0.26</td>
</tr>
<tr>
<td>Kufri Chipsona-2</td>
<td>32.3</td>
<td>86.9</td>
<td>103.9</td>
<td>344.9</td>
<td>588.1</td>
<td>307.5</td>
<td>358.6</td>
<td>448.9</td>
<td>0.20</td>
</tr>
<tr>
<td>CD (P&lt;sub&gt;0.05&lt;/sub&gt;)</td>
<td>5.0</td>
<td>7.5</td>
<td>11.0</td>
<td>NS</td>
<td>60.9</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>-</td>
</tr>
</tbody>
</table>

All three growth parameters were significantly higher in Kufri Chipsona-2 as compared to Kufri Chipsona-1, which may be attributed to its growth habit governed by genetic traits. Similar findings were also reported earlier from same location (9).

There was an increase in processing grade and total tuber number with increasing P application in comparison to control up to the level of 80 kg P\textsubscript{2}O\textsubscript{5}/ha (Table 1). At 80 kg P\textsubscript{2}O\textsubscript{5}/ha dose, the increase over control was 8.6% in processing grade tuber number and 11.9% in total tuber number/ha. Significant increase in tuber number in response to P application has been reported earlier (3).

Processing grade tuber number was at par in Kufri Chipsona-1 and Kufri Chipsona-2. However, total tuber number was lower by 16.1% in Kufri Chipsona-2 as compared to Kufri Chipsona-1. This may be due to low average tuber number/plant in Kufri Chipsona-2 than Kufri Chipsona-1. These findings are in confirmation with those reported by Kumar et al. (9).

Yield: Response to P fertilization was significant with respect to processing grade yield, total
tuber yield and biomass yield (Table 1). But appreciable upward trend in above stated parameters was noticed up to 80 kg P$_2$O$_5$/ha. Further increment in P dose beyond 80 kg resulted in non-significant fall in processing as well as total tuber yield, but again slight increase was observed in processing-grade and total tuber yield when P dose increased from 120 to 160 kg P$_2$O$_5$/ha. Both the decreasing and increasing trend in tuber yield beyond 80 kg P were non-significant. The increase in processing grade and total tuber yield due to application of 80 kg P$_2$O$_5$/ha was 7.7 and 9.3%, respectively as compared to control. The higher tuber and biomass yield due to P fertilization could be due to higher cell division and elongation that ultimately lead to more photosynthesis and translocation of photosynthates to the tuber by the plants as evident by higher growth characters due to P application. Between the two varieties, processing grade yield, total tuber yield and biomass yield were higher in Kufri Chipsona-1 than Kufri Chipsona-2; however, the differences were statistically not significant. These results are also supported by Singh et al. (11).

Phosphorus use efficiency: The trend of phosphorus use efficiency (PUE) due to P application was same in both the cultivars. There was sharp increase in PUE when P dose was increased from 0 to 80 kg P$_2$O$_5$/ha. Thereafter, sharp decline in PUE was observed when P dose was further increased from 80 to 120 kg P$_2$O$_5$/ha (Table 1). There was slight increase in the PUE when P dose was further increased from 120 to 160 kg/ha. This can be partially explained by the law of diminishing return. PUE was higher in Kufri Chipsona-1 (0.26) as compared to Kufri Chipsona-2 (0.20).

Economics: It was found that both the variables viz., net returns to the growers and benefit cost ratio (B: C ratio) were highest (Rs 59,503 and 2.43, respectively) when 80 kg P$_2$O$_5$/ha was applied. It was further observed that any increase in P dose beyond 80 kg led to non-significant decrease in net returns as well as B: C ratio (Table 1). The maximum returns at 80 kg P$_3$O$_5$ was because the highest tuber yield was also recorded at this dose. Net returns and B: C ratios were statistically similar in both the cultivars.

Quality parameters: Processing quality traits viz., specific gravity, tuber dry matter content, chip colour at harvest and after five-month storage at elevated temperature of 10-12°C with fogging of sprout suppressant (CIPC) were not influenced by P levels (data not shown). In the present study, reducing sugars were also not affected by different P levels. On the contrary, P nutrition has been reported to increase reducing sugars content at harvest and after storage (6). All the quality parameters were in acceptable limits to the processing industry. These findings are in confirmation with the earlier findings of Kumar et al. (8) reported for Kufri Jyoti.

The results of the study clearly indicated that for getting highest tuber yield and maximum net returns from Chipsona varieties, the P dose should be 80 kg P$_2$O$_5$/ha. Adding more than 80 kg P$_2$O$_5$ had depressing effect on yield and led to lower net returns.

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LITERATURE CITED


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