Abstract
The introduction of submergence-tolerant SUB1 rice varieties has enhanced productivity of average lowland rice yields by over 2 t ha\(^{-1}\). Considering the benefit of these varieties the government of Uttar Pradesh has launched a large-scale seed production program to greatly increase the cultivation of the Swarna-Sub1 variety in the flood-prone, rainfed lowlands of eastern UP. However, relatively little is known concerning nutrient management, especially that of potassium (K), phosphorus (P) and nitrogen (N), to provide the best potential for the growth of SUB1 rice varieties. This question is investigated in nursery applications in a study carried out at the Instructional Farm of Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad (UP), India.

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The Beneficial Effects of Applying Potassium Alone or with Phosphorus During Nursery Management in Enhancing the Survival and Yield of the Rice Variety Swarna-Sub1 in a Flood-Prone Ecosystem

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Kumarganj, Faizabad, India during the 2010 and 2011 kharif seasons. Seven nutrient treatments, representing nursery nutrient management were applied 10 days after seed sowing with various combinations of fertilizers, with N supplied as urea, P as single superphosphate and K as muriate of potash. The 25-day old seedlings obtained were transplanted in an outdoor submergence pond. Fifteen days after transplanting, plants were submerged for a period of 13 days. Survival and recovery were recorded five and 15 days after desubmergence, respectively. Growth observations and nutrient analyses were carried out at different stages of crop growth, i.e. just before transplanting, before submergence, just after desubmergence and at the recovery stage. A significantly higher survival rate after desubmergence was recorded in treatment T1, when K was applied alone (0-0-40 kg N-P$_2$O$_5$-K$_2$O ha$^{-1}$) and in T2, when K was applied together with a higher dose of P in the nursery treatment (0-60-40 kg N-P$_2$O$_5$-K$_2$O ha$^{-1}$). Maximum underwater shoot elongation (25.4%) was recorded in T5 (40-40-40 kg N-P$_2$O$_5$-K$_2$O ha$^{-1}$) when K and P were supplied with N, whereas at recovery, greater plant heights were 4.4 million ha are highly submergence-prone (intermediate rainfed lowlands; Haefele and Hijmans, 2007). In addition, submergence might also occur in shallow rainfed lowlands and irrigated lowlands. Recent research has identified the SUB1 gene as the main gene controlling submergence tolerance in rice. The cloning of the gene underlying tolerance (Xu et al., 2006) has enabled the development of precise marker targeted transfer of this gene into widely accepted “mega varieties” (Neeraja et al., 2007; Septiningsih et al., 2009) through a marker-assisted backcrossing approach. The effects of SUB1 on plant survival under submergence are dramatic, and the gene has no yield penalty under non-submerged conditions. Results of research carried out by the International Rice Research Institute (IRRI) showed that SUB1 varieties gave an average of 1.3-8.1 t ha$^{-1}$ higher yield than non-SUB1 types under 12-17 days of complete submergence (Singh et al., 2009). Similar results were also obtained on farmers’ fields in several states in India, namely Uttar Pradesh (UP), Bihar, West Bengal and Orissa. In some cases, SUB1 varieties gave a near normal yield under submergence while intolerant varieties were irretrievably damaged (Mackill et al., 2012). In India, Swarna-Sub1 was released by the states of UP and Orissa in 2012 and this variety has enhanced the productivity of rice by 1-2 t ha$^{-1}$ compared to the average lowland yield.

Considering the benefit of the Swarna-Sub1 variety, the UP government has launched a large-scale seed production program for Swarna-Sub1, increasing its cultivation extensively. However, limited progress has been made in the development of accompanying crop and nutrient management options to harness the potential of the newly developed SUB1 introgressed rice varieties. Recent research has shown that leaf N concentration is negatively correlated with plant survival under flooded conditions, and addition of P seems to enhance tolerance of plants grown on P-deficient soils (Elia and Ismail, 2006). Furthermore, unpublished results indicate that low as well as high leaf nitrogen (N) concentrations reduce survival, whereas zinc (Zn) application on Zn deficient soils increases survival. Interestingly Wade et al. (1999) reported that slow release N fertilizer was the most beneficial fertilizer in submergence-prone rainfed lowlands. Additionally, balanced nutrition (N-P-K-Zn) with farm yard manure (FYM) together with lower seed density in the seed bed, and the transplanting of older seedlings, also significantly enhanced survival following flooding after transplanting (Bhowmick et al., 2014).

Very little work has been conducted on the effect of potassium (K) nutrition on yield improvement under flood prone situations. However, available information on nutrient management after flooding (recovery) shows that a significant increase in yield can be achieved through application of nutrients, particularly N, because of its effects in stimulating recovery growth and early tillering (Ram et al., 2009). Thus, there are clear indications that crop and nutrient management may have a major impact on the performance of these SUB1 varieties. Given the fact that Swarna-Sub1 has already been released in India and Bangladesh, and its release is pending in several other countries, there is an urgent need to obtain more information on the effects of nursery nutrient management. The purpose of this work was therefore to investigate the influence of nutrient management, especially that of K, in relation to the high potential of Swarna-Sub1 to withstand submergence induced by flooding.

**Materials and methods**

Site description

The investigation was carried out during the 2010 and 2011 kharif seasons at the Instructional Farm, Department of Crop Physiology, Narendra Deva University of Agriculture and Technology (NDUAT), Kumarganj, Faizabad, UP, India. This site lies in the...
Gangetic alluvium of eastern UP, situated at latitude 26°47' North and longitude 82°12' East and at an altitude of 113 m above sea level. This is in a semi-arid zone receiving a mean annual rainfall of above 1,100 mm, of which about 80% is precipitated during the monsoon season (July to end of September) with the remainder falling mainly as showers in winter. The pooled nursery physico-chemical soil test results of the experimental site in 2010 and 2011 were as follows: sand 35.20%, silt 48.60%, clay 16.20%, field-capacity 39.60%, bulk density 1.3 g cm$^{-2}$, pH 7.6, EC 0.2 dS m$^{-1}$, organic carbon 0.3%, available N 57 ppm, available P$_2$O$_5$ 7 ppm (NaHCO$_3$ pH 8.5) and available K 218 ppm. Nitrogen, phosphorus (P) and K content were estimated and calculated according to the methods given by Subbiah and Asiza (1956), Jackson (1969), and Olsen et al. (1954), respectively.

Observations and statistical analysis
Observations on various growth parameters - plant height (cm), dry shoot biomass (g), and yield (t ha$^{-1}$) - were recorded. Plant numbers plot$^{-1}$ were counted before, and at recovery, while plant height was recorded before transplanting, before submergence, after desubmergence and at recovery. Dry shoot biomass per plant was determined before transplanting, and at recovery.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>N-P-K</th>
<th>N, P$_2$O$_5$, K$_2$O</th>
</tr>
</thead>
<tbody>
<tr>
<td>T$_1$</td>
<td>N-P-K</td>
<td>40-40-40</td>
</tr>
<tr>
<td>T$_2$</td>
<td>N</td>
<td>40-0-0</td>
</tr>
<tr>
<td>T$_3$</td>
<td>P-K</td>
<td>0-40-40</td>
</tr>
<tr>
<td>T$_4$</td>
<td>P</td>
<td>0-40-0</td>
</tr>
<tr>
<td>T$_5$</td>
<td>K</td>
<td>0-0-40</td>
</tr>
<tr>
<td>T$_6$</td>
<td>P-K</td>
<td>0-60-40</td>
</tr>
<tr>
<td>T$_7$</td>
<td>P</td>
<td>0-60-0</td>
</tr>
</tbody>
</table>

Table 1. N-P-K treatments applied at the experiment.

Data analysis and statistical analysis
The data were analyzed using SPSS 17.0 software. The means were compared using Duncan's multiple range test at 5% level of probability.
before submergence and after desubmergence, while grain yields were recorded at maturity of all treatments on a per plot basis which was converted into t ha⁻¹. The samples were oven dried at 70°C to obtain constant weight. All these observations were recorded on 10 initially tagged hills from each plot. Grains were harvested, dried, and weighed. Concentrations of N, P and K in the dried shoot material were determined in plants obtained before transplanting, before submergence and after desubmergence using methods described by Lindner (1944) and Jackson (1973). Nutrient uptakes were calculated as the product of concentration and biomass. Collected data were analyzed statistically following the method of Gomez and Gomez (1984).

### Results and discussion

#### Survival and growth parameters

A higher percentage of plant survival was recorded with a nursery application of 40 kg K₂O ha⁻¹ alone (T₅) or together with 60 kg P₂O₅ ha⁻¹ (T₆). Minimum survival was recorded when 40 kg N ha⁻¹ (T₂) or 40 kg P₂O₅ ha⁻¹ (T₄) were applied (Table 2). The increased mortality in T₂ and T₄ treatments suggests that application of only N or P fertilizers were unable to maintain normal growth and biochemical processes during submergence to support a rapid detoxification of oxygen free radicals which cause damage to plants after desubmergence. We suggest that the beneficial role of K fertilizer alone during nursery application or with a higher dose of P might have resulted for two reasons.

The first could be due to the greater capability of these plants to maintain internal gas diffusion or energy levels to sustain normal growth and developmental processes during submergence, and the second might be due to the ability of the this SUB1 gene introgressed variety to enable quick responses of anti-oxidative defense mechanisms after desubmergence. According to Shabala and Pottosin (2014), reactive oxygen species (ROS) production is a major reason for excessive K losses from the shoots of rice plants during submergence. This occurs because unsaturated triglycerides of the membrane lipid bilayer are attacked primarily by ROS leading to destruction of membrane integrity and a leakage of K from the plant. Higher K concentrations in the shoot may thus be an important trait for increasing survival under lowland conditions where flooding is common during the early stage of crop establishment. Moreover, plants supplied with additional K (and P) are better able to avoid K deficiency than those not supplied. Potassium plays a major role in photosynthesis and, when K is deficient, ROS production and their detrimental effect is increased intensely (Cakmak, 2005). In practical terms in the field, avoidance of K deficiency is a major reason for K application.

### Table 2. Effect of nursery nutrient management on survival, regeneration and new leaf emergence of Swarna-Sub1 rice variety.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>N, P₂O₅, K₂O application</th>
<th>Plant no. plot¹</th>
<th>Survival(%)</th>
<th>New leaf emergence (DAD)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kg ha⁻¹</td>
<td>BS</td>
<td>AS</td>
<td>AR</td>
</tr>
<tr>
<td>T¹</td>
<td>40-40-40</td>
<td>134.3</td>
<td>108.7</td>
<td>129.6</td>
</tr>
<tr>
<td>T₂</td>
<td>40-0-0</td>
<td>135.0</td>
<td>96.3</td>
<td>129.0</td>
</tr>
<tr>
<td>T₃</td>
<td>0-40-40</td>
<td>132.0</td>
<td>115.0</td>
<td>121.0</td>
</tr>
<tr>
<td>T₄</td>
<td>0-40-0</td>
<td>122.6</td>
<td>92.0</td>
<td>119.0</td>
</tr>
<tr>
<td>T₅</td>
<td>0-0-40</td>
<td>128.6</td>
<td>116.7</td>
<td>125.3</td>
</tr>
<tr>
<td>T₆</td>
<td>0-60-40</td>
<td>127.6</td>
<td>114.7</td>
<td>126.0</td>
</tr>
<tr>
<td>T₇</td>
<td>0-60-0</td>
<td>125.0</td>
<td>106.3</td>
<td>125.0</td>
</tr>
<tr>
<td>LSD at 5%</td>
<td></td>
<td>2.98</td>
<td>6.35</td>
<td>6.99</td>
</tr>
</tbody>
</table>

Note: BS: Before submergence; AS: After desubmergence (after 13 days of complete submergence); AR: At recovery (15 days after desubmergence); DAD: Days after desubmergence.

¹Survival was recorded five days after desubmergence.

15 days after transplanting, plants were completely submerged for 13 days in an outdoor pond under natural conditions.

Submerged rice seedlings. Photo by E. Sokolowski.
15 days after transplanting, plants were completely submerged for 13 days in an outdoor pond under natural conditions.

Note: T1: 40-40-40 kg N-P-K ha$^{-1}$, T2: 40-0-0 kg N-P-K ha$^{-1}$, T3: 0-40-40 kg N-P-K ha$^{-1}$, T4: 0-40-0 kg N-P-K ha$^{-1}$, T5: 0-0-40 kg N-P-K ha$^{-1}$, T6: 0-60-40 kg N-P-K ha$^{-1}$, T7: 0-60-0 kg N-P-K ha$^{-1}$. 

Table 3. Effect of nursery nutrient management on plant height and elongation rates (%) of Swarna-Sub1.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>N, P$_2$O$_5$, K$_2$O Application</th>
<th>Plant Height</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>BT</td>
</tr>
<tr>
<td>T1</td>
<td>40-40-40 kg ha$^{-1}$</td>
<td>17.67</td>
</tr>
<tr>
<td>T2</td>
<td>40-0-0 kg ha$^{-1}$</td>
<td>15.93</td>
</tr>
<tr>
<td>T3</td>
<td>0-40-40 kg ha$^{-1}$</td>
<td>14.67</td>
</tr>
<tr>
<td>T4</td>
<td>0-40-0 kg ha$^{-1}$</td>
<td>13.90</td>
</tr>
<tr>
<td>T5</td>
<td>0-0-40 kg ha$^{-1}$</td>
<td>14.07</td>
</tr>
<tr>
<td>T6</td>
<td>0-60-40 kg ha$^{-1}$</td>
<td>16.77</td>
</tr>
<tr>
<td>T7</td>
<td>0-60-0 kg ha$^{-1}$</td>
<td>14.13</td>
</tr>
</tbody>
</table>

$^{(1)}$Figures in parenthesis are percent increase at AS over corresponding values of BS.

$^{(2)}$Figures in parenthesis are percent increase at AR over corresponding values of AS.

The various nutrient combinations applied during nursery management induced significant differences in plant height of the seedlings measured before uprooting for transplanting (Table 3). Heights ranged from 13.9 to 17.7 cm with maximum height recorded in T$_1$ (17.7 cm) (40-40-40 kg N-P-K ha$^{-1}$), followed by T$_7$ (16.8 cm) (0-60-40 kg N-P-K ha$^{-1}$) with a minimum height being observed in T$_4$ (13.9 cm) (0-40-0 kg N-P-K ha$^{-1}$).

According to Yoshida (1981), “Plant height is an important plant trait that is controlled by the genetic makeup of the plant as well as the growing conditions, seedling vigour and nutrient status.” The greater plant height in T$_1$ seems likely be associated with the more balanced nursery nutrient supply. Phosphate supplied alone at the lower rate (T$_4$) resulted in the lowest plant height but when associated with K (and no N)(T$_7$) it produced a significantly greater plant height (16.8 cm) (Table 3). Before submergence, 15 days after transplanting, maximum plant height was recorded in T$_1$ (0-60-0 kg N-P$_2$O$_5$-K$_2$O ha$^{-1}$), which was significantly superior to all treatments except T$_2$; a minimum height was recorded in T$_1$. Immediately after desubmergence shoot heights were again measured and shoot percentage elongation during the period of submergence was recorded in all treatments. These ranged from the lowest at 14.2% (T$_5$) to the highest at 25.4% (T$_1$). Unlike deep water and other aquatic plants, the importance of slow growth in rainfed lowland rice during submergence has been suggested to be beneficial in that it prevents damage due to lodging once water recedes following a flash flood (Singh, 2001; Jackson and Ram, 2003; Srivastava, 2007). Elongation rates ranged from a maximum of 0.54 cm day$^{-1}$ (T$_1$) closely followed by 0.52 cm day$^{-1}$ (T$_5$) to a minimum of 0.34 cm day$^{-1}$ (T$_2$) (Fig. 1). At recovery, maximum plant height was recorded in T$_1$ (48.83 cm) followed by T$_6$.
Seeding dry weights (Table 4) varied significantly from 0.51-0.57 mg, at transplanting, the maximum being recorded in T6 (0.61 mg) followed by T7 (0.57 mg) (Table 4). After desubmergence, higher seeding dry weights were recorded for all treatments, with a maximum increase in height was recorded in T5 (43.7%) with a minimum (25.5%) in T4 (Table 3).

Before transplanting and before submergence maximum N concentration was recorded in T2 (0-60-40 kg N-P-K ha⁻¹), whereas after desubmergence, it was recorded in T6 (40-0-0 kg N-P-K ha⁻¹), probably as a consequence of N application in both these treatments (Table 5). Maximum P concentrations (before transplanting and before submergence) were recorded in T6 (0-60-40 kg N-P-K ha⁻¹), whereas after desubmergence these were recorded in T1 (0-60-0 kg N-P-K ha⁻¹), which had the same P status as T6 (0-40-0 kg N-P-K ha⁻¹). Maximum K concentration before transplanting was recorded in T6 (0-40-40 kg N-P-K ha⁻¹) whereas before submergence and after desubmergence maximum K concentrations were recorded in T1 (0-0-40 kg N-P-K ha⁻¹) and T4 (0-60-40 kg N-P-K ha⁻¹), respectively.

Nutrient analysis, uptake and yield
Before transplanting and before submergence maximum N concentration was recorded in T2 (40-0-0 kg N-P-K ha⁻¹), whereas after desubmergence, it was recorded in T5 (40-40-40 kg N-P-K ha⁻¹), probably as a consequence of N application in both these treatments (Table 5). Maximum P concentrations (before transplanting and before submergence) were recorded in T6 (0-60-40 kg N-P-K ha⁻¹), whereas after desubmergence these were recorded in T1 (0-60-0 kg N-P-K ha⁻¹), which had the same P status as T6 (0-40-0 kg N-P-K ha⁻¹). Maximum K concentration before transplanting was recorded in T6 (0-40-40 kg N-P-K ha⁻¹) whereas before submergence and after desubmergence maximum K concentrations were recorded in T1 (0-0-40 kg N-P-K ha⁻¹) and T4 (0-60-40 kg N-P-K ha⁻¹), respectively.

Ella and Ismail (2006) reported that a high N concentration of rice leaves was not beneficial when rice was subjected to flash flooding at an early stage and also that application of N alone was prejudicial to survival. Reserves of shoot carbohydrates were very quickly exhausted and severe post-oxidative damage occurred. However, N accompanied by P and K substantially improved survival of the SUBI introgressed cultivar Swarna-Sub1. In this regard, Singh (2011) has reported

### Table 4. Effect of nursery nutrient management on the dry weight of Swarna-Sub1.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>N, P₂O₅, K₂O application</th>
<th>Plant dry wt.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kg ha⁻¹</td>
<td>BT</td>
</tr>
<tr>
<td>T₁</td>
<td>40-40-40</td>
<td>0.53</td>
</tr>
<tr>
<td>T₂</td>
<td>40-0-0</td>
<td>0.51</td>
</tr>
<tr>
<td>T₃</td>
<td>0-40-40</td>
<td>0.53</td>
</tr>
<tr>
<td>T₄</td>
<td>0-40-0</td>
<td>0.52</td>
</tr>
<tr>
<td>T₅</td>
<td>0-0-40</td>
<td>0.53</td>
</tr>
<tr>
<td>T₆</td>
<td>0-60-40</td>
<td>0.57</td>
</tr>
<tr>
<td>T₇</td>
<td>0-60-0</td>
<td>0.55</td>
</tr>
<tr>
<td>LSD at 5%</td>
<td></td>
<td>0.001</td>
</tr>
</tbody>
</table>

¹Figures in parenthesis are per cent increase at AS over corresponding values of BS.

### Table 5. Effect of nursery nutrient management on N, P and K shoot concentrations of Swarna-Sub1 exposed to early stage submergence (5 days).

| Treatment | N, P₂O₅, K₂O application | N | P | K | N | P | K | N | P | K | N | P | K |
|-----------|--------------------------|---|---|---|---|---|---|---|---|---|---|---|---|---|
|           | kg ha⁻¹                  | BT | BS | AS | BT | BS | AS | BT | BS | AS | BT | BS | AS |
| T₁        | 40-40-40                 | 4.02 | 0.77 | 1.66 | 3.83 | 0.94 | 2.29 | 3.83 | 0.88 | 1.68 |
| T₂        | 40-0-0                   | 4.20 | 0.66 | 1.63 | 3.93 | 0.44 | 2.08 | 3.84 | 0.99 | 1.14 |
| T₃        | 0-40-40                  | 3.02 | 0.75 | 1.86 | 3.81 | 0.98 | 2.26 | 3.42 | 0.14 | 1.62 |
| T₄        | 0-40-0                   | 3.21 | 0.78 | 1.64 | 3.24 | 0.96 | 2.12 | 3.14 | 0.13 | 1.22 |
| T₅        | 0-0-40                   | 3.30 | 0.74 | 1.84 | 3.42 | 0.45 | 2.38 | 3.23 | 0.10 | 1.47 |
| T₆        | 0-60-40                  | 3.43 | 1.05 | 1.83 | 3.71 | 1.25 | 2.36 | 3.49 | 0.16 | 1.70 |
| T₇        | 0-60-0                   | 3.35 | 1.04 | 1.66 | 3.53 | 1.02 | 2.28 | 3.41 | 0.17 | 1.46 |
| LSD at 5% |                          | 0.11 | 0.03 | 0.05 | 0.07 | 0.01 | 0.06 | 0.08 | 0.01 | 0.12 |

Note: BT: Before transplanting; BS: Before submergence; AS: After desubmergence (after 13 days of complete submergence).
that higher regeneration of plants after desubmergence in treatments (applied with doses of N, P and K during nursery management) was associated with the first dose of N applied in the field (five days after desubmergence) rather than the N applied in the nursery, with P and K.

Nitrogen, P, and K uptakes (g ha\(^{-1}\)) before transplanting, before submergence and after desubmergence are shown in Fig. 2 (A-C). The pattern of N uptake was similar in all stages, showing higher uptake in treatments supplied with higher N (T\(_1\) and T\(_2\)). After desubmergence, a sharp decrease in N uptake was noticed in T\(_4\) (0-40-0 kg N-P-K ha\(^{-1}\)) probably due to an interaction between P and N uptake during submergence (Fig. 2A). A higher uptake of P before transplanting was recorded in T\(_6\) and T\(_7\) treatments due to higher P doses (40 and 60 kg ha\(^{-1}\)), however T\(_7\) recorded lower P uptake than T\(_6\). Lower P uptake was recorded in T\(_2\) and T\(_5\) (solely applied N and K fertilizers respectively) than the rest of the treatments before submergence. After desubmergence, higher P uptake was recorded in all treatments presumably due to increased availability of P in the submerged soil (Singh, 2011) (Fig. 2B). Higher uptake of K before transplanting was recorded in treatments supplied with K doses. Interestingly, the higher dose of P along with K (T\(_6\); 0-60-40 kg N-P-K ha\(^{-1}\)) produced a significantly higher K uptake than a lower dose of P (T\(_7\); 0-40-40 kg N-P-K ha\(^{-1}\)). Higher K uptake before submergence was recorded in all treatments compared to their respective values before transplanting. After desubmergence a drastic reductive K uptake pattern was recorded in all treatments (Fig. 2C) with higher reduction in treatments with N and P alone (T\(_2\), T\(_4\) and T\(_7\)).

Maximum grain yield (t ha\(^{-1}\)) was recorded in T\(_5\) (0-0-40 kg N-P-K ha\(^{-1}\)), which was significantly superior to all other treatments except T\(_7\) (0-60-40 kg N-P-K ha\(^{-1}\)). Higher P...
doses alone, or together with K, (T7; 0-60-0 kg N-P-K ha⁻¹ and T6; 0-60-40 kg N-P-K ha⁻¹) produced higher yields than lower doses of P (T4; 0-40-0 kg N-P-K ha⁻¹ and T3; 0-40-40 kg N-P-K ha⁻¹). Difference in yield due only to a higher P dose, however, was not significant whereas yield differences resulting from different K doses were significant (Fig. 3). Lowest grain yield was recorded in T2 (40-0-0 kg N-P-K ha⁻¹). These findings clearly indicate that nursery application of N fertilizer alone produced a detrimental effect after desubmergence, by decreasing the survival and/or initial crop stand (Table 2). This was associated with a slower recovery and growth, which might have influenced the yield attributing traits (data not shown), ultimately affecting yield. The influence of K supply during seedling growth before transplanting was shown to have a major positive impact on subsequent plant development. The K concentration of the seedlings and K uptake were negatively correlated with survival (-0.58 and -0.36 respectively).

**Conclusions**
The results of the experiment indicated that 40 kg K₂O ha⁻¹ alone or supplied together with 60 kg ha⁻¹ P₂O₅ fertilizer produced significantly higher survival rates, and thereafter helped in rapid regeneration, which was reflected in the form of higher yield. Proper nursery nutrient management using K can contribute considerably to maximizing submergence tolerance and grain yield of the rice crop in the field. A slightly higher dose of P, along with the normal K dose, also produced a higher yield than the normal P dose used in nursery management. These results, however, need further validation on farmers’ fields applying lower N doses with K and P.

**Acknowledgement**
The authors are grateful to the Narendra Deva University of Agriculture and Technology for providing technical support for experimental work, including soil analysis and nutrient analysis in plants. The authors would also like to thank Rastriya Krishi Vikas Yojna, the Government of Uttar Pradesh and the International Potash Institute for providing the financial support for this project.

**References**


