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Effect of mother plant applied nitrogen and potassium on the sowing value of true potato seed

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Abstract

A screenhouse experiment was conducted during 1996 short rains to assess carry-over effects of mother plant-applied nitrogen and potassium on seedling emergence, seedling vigour and dry matter accumulation of Solanum potato seedlings from true potato seed (TPS). Hybrid TPS was obtained from a cross between CIP 381379 (Kisoro) and Rutuku. Kisoro mother plants received N rates of 0, 120 and 240 kg ha^{-1}, and potassium rates of 0, 132.8 and 265.6 kg ha^{-1}. Performance of seed lots from the different fertiliser treatment combinations was compared to that of imported hybrid progenies, IP 88001, IP 88006 and KP 90178,8 obtained from mother plants supplied with 500 kg DAP ha^{-1}. Mother plants supplied with 120 and 132.8 kg N and K, respectively, produced true seed with high seedling emergence and vigour (sowing value), comparable to that of imported hybrid TPS.

Key words: TPS, Nitrogen, Potassium, Quality

Introduction

True Potato Seed (TPS) has shown to be a viable solution for producing seedling tubers in tropical areas where the acquisition of good quality *Solanum* seed tubers is prohibitively expensive (Malagamba, 1988). One of the major constraints to sowing TPS as an alternative to planting seed tubers for potato production, however, is the low seedling vigour of the TPS during early emergence under field conditions.

The genetic constitution of the seed and the environmental conditions subjected to the seed before and after harvest, affect its emergence and field establishment (Harrington, 1971; Ross, 1980). Seed production and quality ultimately depend on flower formation, flowering intensity, nutrient flow from the mother plants, preceding fertilisation and formation of the gametophyte. Other environmental factors that may affect seed formation and development include; temperature, light, water and the kind and quantity of available nutrients (Pallais et al., 1987).

The production of vigorous seed is generally associated with ideal growing conditions of the mother plants. Conditions that do not promote complete seed development, therefore, result in lack of uniform germination, low seedling vigour and decreased seed performance under field conditions (Dickson, 1980; Gray and Thomas, 1982). Increased assimilate transport towards the developing reproductive structures during seed development is required for production of high quality seed (Krauss, 1978).

In tobacco, increased N application to the mother plants, increased seed germination rate and enhanced its uniformity. In lettuce, a linear relationship was found between seed vigour, nitrogen supply and soil fertility (Soffer and Smith, 1974). Higher yields were obtained from bean (*Phaseolus vulgaris*) seed of low weight but high in N content than from heavy seed with low N content (Ries et al., 1970).

These findings indicate that edaphic conditions present during mother plant and seed development can significantly affect the quality of the seed produced. However, the specific mother plant nutritional requirements for the production of high quality TPS have not been investigated under Ugandan conditions. This study was conducted to assess the carry-over effects of N and K application to potato mother plants on true potato seed quality, in terms of seedling emergence, seedling vigour and dry matter accumulation of the seedlings

Materials and Methods

Potato mother plants of genotype CIP 381379.9 (Kisoro), a high-yielding improved variety grown in Uganda, were raised at Kalengyere Research Station (2450 masl) during 1995 long rains. Three levels of potassium; 0 , 132.8 and 265.6 kg K ha^{-1} and nitrogen; 0, 120 and 240 kg N ha^{-1} in all combinations, were applied to the experimental plots at planting. Muriate of potash (KCl) and Urea were the K and N sources, respectively. All the KCl rates and half the rates of urea were applied into the furrows and mixed with

randomised complete block with three replications. Plot size was 7.0 m x 2.0 m and consisted of three rows each of 15 tubers spaced at 1 m x 0.5 m, inter- and intra-row respectively. Uniform size tubers (about 60 g) at about the same physiological age were used for the experiment. Rutuku, a popular local variety, was planted in separate plots and was used as the pollen source for hybrid TPS produced from a cross between Kisoro (?) and Rutuku (?). The crop was hand-weeded twice and light hilling done at the second weeding.

Forty five days after planting, pollen was collected from Rutuku pollen donor plants into vials using a hand vibrator. Two to three flower buds at the late bud stage or early unfolding stage were selected from Kisoro mother plants from the two middle rows nf each plot. They were emasculated by carefully removing the anthers using a scalpel and hand pollinated in the early mornings.

Berries were harvested 5 to 6 weeks after pollination when the berries started to ripen. Berries from each plot were collected in polyethylene bags, counted and weighed using a top-loading Harvard Trip Balance (OHAUS). They were then ripened in polythene bags at 27±2 °C for about six days. Seeds were extracted on to a 0.5 mm sieve, under a tap of running water, cleaned and dried at room temperature (27 °C). The seed was stored in paper envelopes in an incubator at about 40 °C for 6 months to break dormancy (Pallais et al., 1990). The seed was later used for seedling vigour and emergence studies in a screenhouse.

Twenty randomly selected seeds from each treatment were sown in wooden trays in two rows of ten seeds each. Seed lots from three treatments were planted in each tray previously filled with sterilised soil (mixture of sand and peat moss in a ratio of 1:1) at a spacing and sowing depth of 5 cm x 2 cm and 0.5 cm , respectively. In addition, three TPS progenies from CIP-Nairobi, IP 88001, IP 88006, and KP 90178.8, were sowed for comparison. The seed had been raised from mother plants supplied with 500 kg diammonium phosphate (DAP) ha^{-1}. The trays were irrigated regularly and uniformly to ensure good moisture supply. Dithane M-45 was used to control seedling damping off. Counts of seedling emergence in each treatment were made daily for 21 days.

Seedlings were cut at soil level 30 days after sowing (DAS), weighed and oven-dried at 70 °C for 48 hours and weighed again. The Coefficient of Velocity of Emergence (CVE) was calculated and used as a measure of emergence rate where a higher CVE value generally indicates more seeds emerged and shorter emergence time (Scott et al., 1984):$CVE = 100\ [\acute{O}N_i/\acute{O}N_iT_i]$, where N is the number of seeds germinated on day i and T is the number of days from sowing. Germination percentage 10, 15 and 21 DAS was calculated as: $100\ [E_n/T]$, where E is the number of seeds emerged on day n and T is the total number of seeds planted; Seedling vigour was evaluated 15 and 21 days after sowing (DAS) using a 1 to 5 scale where 1 = small seedlings with stunted growth, 2 = moderate growth but visually stunted, 3 = good growth, 4 = Vigorous, tall plants with green foliage and 5 = vigorous, green, strong stem, ready to transplant. Percentage seedling emergence data was arcsine transformed (Gomez and Gomez, 1984). Data were analysed using the General Linear Model procedure (SAS, 1990).

Results

Seedling vigour varied among the TPS progenies ranging from visually stunted seedlings to vigorous ones. Vigour scores were generally higher in the local hybrid seed than in the imported hybrid seed although 265.6 kg ha^{-1} produced the most stunted and weakest seedlings and had consistently lower emergence than the other treatments (Table 1). On the contrary, N application rate improved seedling vigour. Seedling vigour scores were 2.3, 3.2 and 4.3 corresponding to N rates of 0, 120 and 240 kg ha^{-1}, respectively. Seedlings from imported seed produced under heavy fertiliser regime (500 kg DAP ha^{-1}) had intermediate vigour but were visually stunted. Dry weight of seedlings did not differ significantly among treatments (Table 1). However, N application to potato mother plants generally favoured dry matter accumulation in the seedlings.

Seedling emergence rate was lowest in seeds produced under high K application (265.6 kg ha^{-1}) and in seeds from mother plants that received no fertiliser (Table 1). Coefficient of Velocity of Emergence of seedlings at K rate of 132.8 kg ha^{-1} was higher than in the seed from mother plants that received no K fertiliser. One of the imported hybrid progenies (IP 88001 had the fastest emergence (CVE = 9.26) compared to 8.93 in the seeds produced from mother plants with no fertiliser. Nitrogen application generally increased seedling emergence. In the first 10 days after sowing (early emergence), K rate increased seedling emergence (%). Both N and K application, however, depressed early emergence. Among the imported TPS progenies, KP 90178.8 had the highest emergence percentage 10 DAS. It was followed by IP 88006 while IP 88001 had the least. Percentage emergence was 37.1, 57.9 and 40.3 at N rates of 0, 120 and 240 kg ha^{-1}, respectively. As expected seedling emergence was higher 15 DAS than 10 DAS in all the TPS lots and the effects of N and K were similar to those at 10 DAS. Final percentage emergence (21 DAS) was depressed by high rates of N and K and was highest in KP 90178.8 (79.6). In the control seed lots, final percentage emergence was 44.9 while in seeds produced under high K fertiliser regime final germination was only 28.4%. Potassium rate of 132.8 kg ha^{-1} and N rate of 120 kg ha^{-1}, however, produced quality seed comparable to that of imported seed produced under high DAP application (Table 1).

Seedling emergence trends are shown in Figure 1. Without N application (Figure 1A), the rate of emergence was lowest at the 265.6 K regime and was highest at 132.8 kg ha^{-1} where the emergence trend was quite comparable to that of the imported seed. When both K and N were applied, the rate of emergence declined indicative of negative interaction between the two mineral nutrients. Nitrogen rate of 120 kg ha^{-1}, applied alone (Figure 1B), produced seed with high rate of seedling emergence comparable to that of KP 90178.8. At the highest N rate (Figure 1C), K rate of 132.8 kg ha^{-1} resulted into seed with high seedling emergence. Potassium rate of 265.6 kg ha^{-1}, however, reduced seedling emergence. Compared to the locally

Table 1. Effect of N and K application to CIP 38179.9 x Rutuku potato mother plants on seedling emergence and vigour during 1996 short rains at Namulonge

Treatmen		SVS	SDW (g)	CVE	FPG (%)
N kg ha^{-1}	K kg ha^{-1}				
0	0	2.3	0.8	8.93	44.9
0	132.8	2.2	0.97	9.09	64.6
0	265.6	1.2	0.10	8.88	28.4
120	0	3.2	1.4	9.17	62.7
120	132.8	2.0	0.53	8.86	44.8
120	265.6	1.8	0.47	8.98	42.9
240	0	4.3	1.5	9.22	51.6
240	132.8	3.0	1.0	9.15	55.6
240	265.6	1.2	0.23	8.91	31.3
IP 88001*		2.2	1.20	9.3	49.9
IP 88006*		2.2	0.90	9.26	62.2
KP 90178.8*		2.0	0.87	8.98	79.6
LSD (0.05)		1.8	NS	0.53	12.5
CV (%)			20.4	3.44	13.7

*Imported hybrid progenies. SDW= Seedling Dry Weight, CVE= Coefficient of Velocity of Emergence, FPG= Final (%) Germination, SVS= Seedling Vigour Score where 1= poor, stunted seedlings and 5 = strong and healthy seedlings.

produced hybrid seed, the imported seed was superior in emergence. It is noteworthy, however, that hybrid seed, whose mother plants were supplied with 120 kg N ha^{-1} or 132.8 kg K ha^{-1}, had similar emergence to IP 88006 and significantly higher emergence than IP 88001 produced from mother plants supplied with 500 kg DAP ha^{-1}.

Discussion

The highest rate of K (265.6 kg ha^{-1}) produced seedlings with the lowest emergence and seedling vigour. In earlier work, (Kanzikwera, unpublished), high K levels were associated with low 100-TPS weight. There is evidence, however, of an association between seed size and/or seed weight and germinability and vigour (Delouche, 1980; Pallais et al., 1987). In fact, seed weight has been proposed as a character for selecting high yielding TPS progenies. (The poor field performance of TPS produced from mother plants supplied with high levels of K, therefore, could be attributed to the low 100-TPS weight produced at these K levels.

Mother plants supplied with 120 kg N ha^{-1} or 132.8 kg K ha^{-1} produced seed that had the highest field performance among the locally produced TPS. However, combination of K and N produced seed of poor quality. Potassium and N application, evidently had negative interaction on seedling emergence. This negative interaction between K and N had also been observed on seed weight of hybrid TPS in earlier work (Kanzikwera, unpublished) and on maize (Karlen et al., 1987). These findings are in agreement with the suggestion that high TPS weight increases seedling vigour and sowing value (Pallais et al., 1987).

The beneficial effects of N to the mother plants has been related to its role in delaying senescence and therefore allowing berries enough time to mature on the mother plant (Delouche, 1980). Fox and Albrecht cited by Delouche (1980) associated rapid germination and vigorous seedlings to high protein content in wheat seed. High protein content in turn was associated with N fertilisation. Lopez and Grabe (1973) reported that application of high N levels to wheat plants increased protein content of the seeds from 6.6 to 10.8%. They further observed that seeds with high protein content germinated faster and developed into larger seedlings compared to average seeds with higher dry matter content in comparison with average seeds. However, increase in seed protein content was accompanied by reduction in seed size and reduced starch content of the endosperm. They concluded that the increase in seed protein due to high N may be restricted to the protein storage species in the endosperm and does not affect embryo and membrane proteins.

Abdul-Baki (1990), proposed that these endosperm protein reserves are important during seedling growth, especially in N deficient soils. Since the increase in endosperm protein content is associated with low endosperm starch content (Lopez and Grabe, 1973), any increase in protein content raises the density of the seed by altering the protein/starch ratio. Hence the trait of high seed density, with high protein and low starch content, may be the same factor that indicates high seed vigour. In studies conducted in Lima, the amount and rate of germination of TPS of different weights were found to be similar although plant size at transplanting was significantly larger for heavy seed than light seed (Malagamba, 1988).

In conclusion, whereas the mechanisms by which N may affect seedling vigour have been reported, knowledge

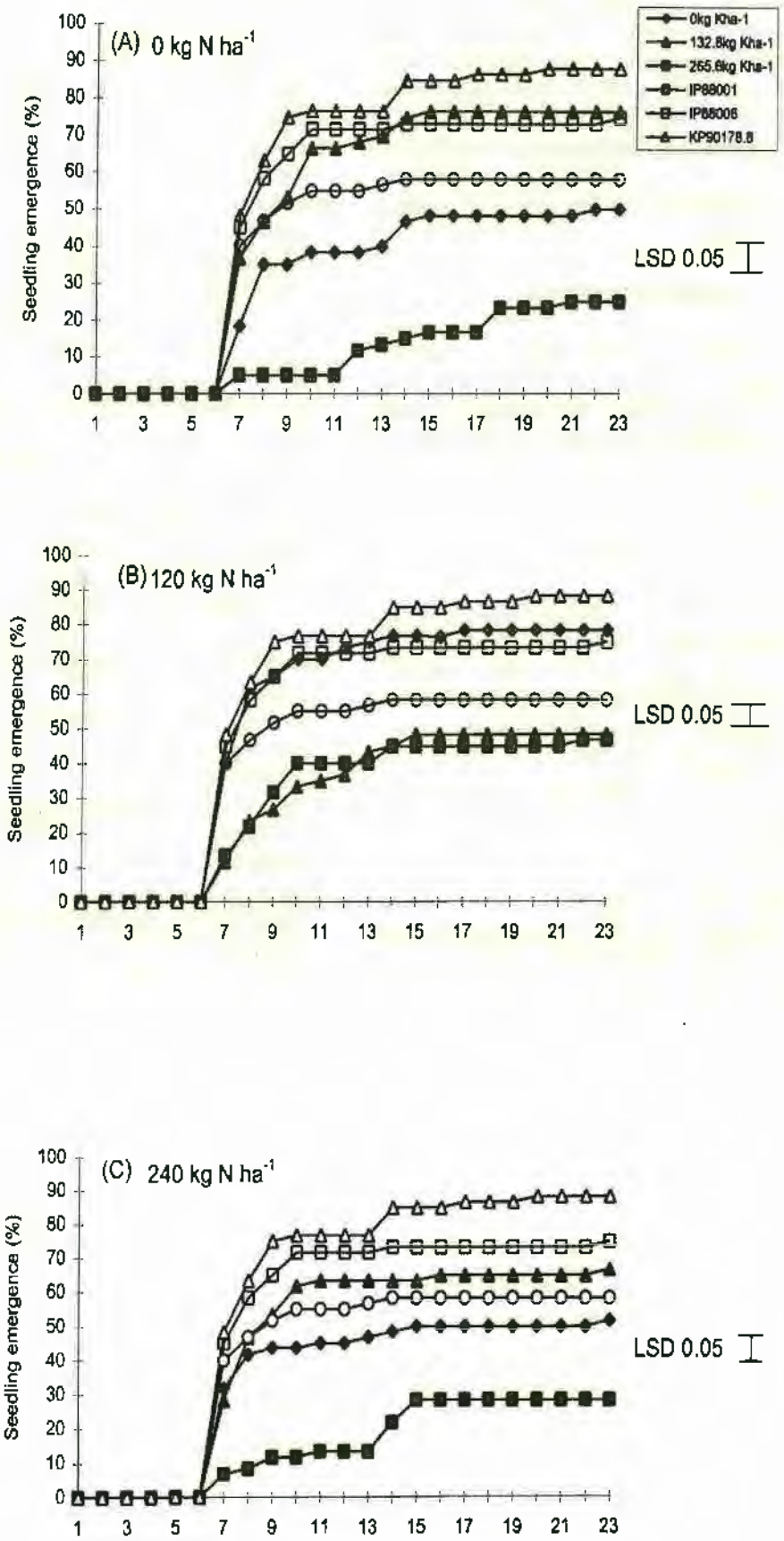

Figure 1- Seedling emergence of hybrid true potato seed CIP 381379.9 x Rutuku as affected by mother plant-applied potassium (A) and nitrogen (B) and (C) at Namulonge

is still lacking as to how K affects seed germinability, seedling emergence and vigour. The results of this study, however, clearly indicated that K increased TPS sowing value and that either N of K could be used to improve field performance of TPS. This is an area that warrants further research. In the present study, using genotype CIP 381379.9 and N and K rates of 120 and 132.8 kg ha^{-1}, respectively, were best for production of TPS with high seedling emergence and vigour.

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