ONION CULTIVAR SELECTION FOR THE LOWLANDS OF CENTRAL PROVINCE IN PAPUA NEW GUINEA

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ABSTRACT

Selected bulb onion cultivars bred in Australia, New Zealand, Japan and the United States were evaluated for production potential under tropical lowland conditions in Papua New Guinea (PNG). Cultivars Rio Enrique, Tropic Brown, Dessex, Yellow Granex, Pira Ouro, Texas Early Grano and Rio Bravo have been identified and recommended for production in the area. Total marketable yield obtained from transplants ranged from 32.1 to 43.6 t/ha. In the lowlands of Central Province, the most suitable planting time is from February to June. However, some cultivars may have potential for late-season planting in July and August.

Key Words: *Onion, Cultivar, Evaluation, Lowlands, Central Province, Papua New Guinea.*

INTRODUCTION

Onion *(Allium cepa)* is a new crop of great economic potential for small-holder farmers in Papua New Guinea (PNG). Currently, PNG relies heavily on imported onions from Australia and New Zealand (NZ) for its domestic consumption. Figures available from July 1987 to June 1988 show that of the 2135 tonnes imported, 1501 tonnes were of Australia origin and the remaining 634 tonnes were from NZ (Wiles, unpublished). At current prices, it is estimated that 5000,000 kina is spent annually on imported onions.

Unconfirmed reports suggest that early missionaries to Manus (2°S) brought some seeds for trial purposes in the 1960s to see if onions could be grown under local conditions. It was not until the 1980s that the Department of Agriculture and Livestock imported some seed material for trials at Laloki (Bull and Bourke 1983; Bull 1985). From these trials, three cultivars were recommended for production in the lowlands of PNG, especially in areas around Port Moresby. Further trials were conducted at Kuk Research Station (1550 m) to identify potential cultivars for high altitude areas. Subsequently, two cultivars were released for production in the highlands (Gunther 1985; Pitt 1988 a).

Small-holder vegetable growers, especially in the highlands, have tried growing fresh bulb onions with some success. The fresh onion bulbs are sold locally. Potential onion growing areas in the highlands and lowlands are those with a distinct dry and wet season. Pitt (1988 a) identified Banz and Minj (Western Highlands); Kainantu, Henganofi and Goroka (Eastern Highlands) as places with a relatively cooler climate which should permit production throughout the year. Potential lowland areas for onion growing are those immediately outside Port Moresby in Central Province (Bull and Bourke 1983; Bull 1985).

The Department of Agriculture and Livestock (DAL) through its Research Division commenced an onion cultivar evaluation program in 1991. The aims of these trials were:

(1) to evaluate the increasing number of new seed material being sold indiscriminately by retailers in PNG without any knowledge of their performance under local conditions, and

(2) to determine a suitable time of planting.

Many onion cultivars developed for temperate or sub-tropical conditions may not necessarily perform well under PNG conditions. Generally, the trails aim to select cultivars that can be promoted for local production; selected cultivars would eventually replace imported onions and capture some economic benefits for local producers.

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Results from this 'elite' cultivar trial would form the basis for a final selection from the cultivars that had been evaluated previously during 1991 and 1992 (Sowei *et al.* unpublished). This report discusses the results from the 'elite' cultivars evaluated at Laloki Agricultural Research Station, Central Province, PNG.

MATERIALS AND METHODS

Nine elite selections of brown onions from the screening and cultivar trials (Kurika *et al.*, unpublished) were evaluated against the two recommended cultivars *viz* Gladalan Brown and Superex (Table 1). The trial was laid out in a completely randomized design (CRD) with 4 replications on a clay loam soil at Laloki Agricultural Research Station (9° S), situated about 15 km from Gordons, Port Moresby, at an altitude of 30 m.

The seedlings were raised in a seed-bed mix of 2 parts black soil, 1 part river soil and 0.5 parts fine sand. The soil was steam sterilized for 2 hours and sieved to obtain a fine mix. Sieved chicken manure droppings obtained from a nearby layer shed were applied at 500 kg/ha, and NPK (12:12:17:2) at the recommended rate. The mixture was watered every day for 1 week before sowing on April 29, 1993. The seeds germinated within 1 week and were maintained for 4 weeks under 50% shade cloth. The seedlings were transplanted at a spacing of 7.5 cm between plants and 30 cm between rows on June 22, 1993.

Plots of 1.5 m x 1.5 m were prepared manually after the field was ploughed using a tractor. Fertilizers (chicken manure and NPK (12:12:17:2)) were applied at recommended rates 1 week before transplanting. Plots were irrigated using watering cans and a lawn sprinkler every day until full establishment at 3 weeks; thereafter watering was done every second day.

Preventative spraying using Benlate (R) and Dithane (R) at 20 grams per 10 litres of water was applied to control purple blotch *(Alternaria porri)*. This treatment, carried out at 2 weeks intervals, started during the last week of May when the seedlings were still in the nursery and continued until leaf fall. On the other hand, onion thrips *(Thrips tabaci)* were controlled by applying Orthene (R) at 10 grams per 10 litres of water. Plots were kept weed free by manual weeding.

After maturing, the onions were field cured before harvesting in September, 1993 (Plate 1). Some late maturing and thick-neck plants were harvested and the tops removed before curing. The onions were graded into large (>50 g) and small (<50 g) bulbs and weighed. Data were subjected to an analysis of variance using a statistical software package, MSTAT Version 4.0.

Storage Observations

After yield measurements were taken, 20 large marketable bulbs were selected from each cultivar for storage observation. The aim was to see how well these bulbs can store under ambient temperature and relative humidity. Bulb weights were monitored weekly for 8 weeks (Table 2).

RESULTS AND DISCUSSION

Yields obtained on the trial (Table 1) indicate that cultivar Rio Enrique produced the highest total marketable yield with large bulbs (>50 g) comprising 97% of that yield. Notwithstanding, the yield of large bulbs of Rio Enrique was not significantly greater than that of the control Gladalan Brown and Superex. However, Rio Enrique produced a significantly greater yield of large bulbs than six of the other eight introduced cultivars. The only cultivars that had a lower large bulb yield than the control cultivar Gladalan Brown were Early Yellow Premium and Early Lockyer Brown which produced low yields of large bulbs (18.0 and 13.3 t/ha, respectively). The latter cultivar is not suitable for early planting, while Early Lockyer Brown developed premature bulbs in the nursery and did not yield well after transplanting into the field.

From the storage observation, it was found that the incidence of fungal rot caused by *Aspergillus niger* was low. Cultivars Superex and Early Yellow Premium had 5% of the bulbs infected while Pira Ouro and Rio Bravo had 10% of the bulbs infected. All other cultivars remained uninfected throughout the 8 weeks storage.

The rate of water loss during storage is a useful guide to determine the keeping quality of onions. Woodman and Barnell (1937) observed that high rates of water loss during drying after harvest were characteristic of non-keeping onions, whereas onions with good storage characteristics lost little water. In this study, water (weight) loss over the storage period for the cultivars tested was monitored over 8 weeks (Table 2). From the seven selections, cultivars Tropic

Brown, Dessex, Yellow Granex and Texas Early Grano lost from 2% to 4% of the moisture content. The highest yielding cultivar in this trial, Rio Enrique, lost 25% of the original weight. This could be related to the bigger bulbs used. Stow (1975) reported that the larger bulbs showed the greatest total loss of weight throughout the storage period. Similar observations were made by Jayabharathi (1989) using *Allium cepa* var. *aggregatum* cultivar Co. 4.

trial (0.13 to 10.2 t/ha) and in the cultivar trial (4.25 to 24.0 t/ha) during the 1991 season (Kurika *et al.*, unpublished). The comparatively low yields obtained in the screening trial were attributed to a severe infestation of purple blotch.

It is generally accepted that all cultivars of the common onion are long-day plants (Call 1986), which tend to form bulbs in long days (Austin 1972).

TABLE 1: **Yield of Onion Cultivars Evaluated at Laloki Agricultural Research Station**

Cultivar	Source	% Dry Matter	Large Marketable Bulbs (t/ha)	Small Marketable Bulbs (t/ha)	Total Marketable Yield (t/ha)
Rio Enrique	Rio Colorado, USA	6.6	42.3 a	1.3 a	43.6 a
Gladalan Brown *	Yates, Australia	7.0	35.2 ab	2.3 ab	37.5 ab
Tropic Brown	Yates, New Zealand	7.4	34.0 ab	4.4 ab	38.3 abc
Superex *	Takii, Japan	7.3	33.4 ab	5.2 ab	38.6 abc
Dessex	Sunseeds, USA	7.7	30.9 abc	4.8 ab	35.7 abcd
Yellow Granex	Sunseeds, USA	6.9	29.4 abc	4.5 ab	33.9 abcd
Pira Ouro	Agroceres, Brazil	11.1	28.4 abc	4.4 ab	32.8 abcd
Texas Early Grano	Yates, Australia	7.6	27.9 abc	10.1 ab	38.0 abcd
Rio Bravo	Rio Colorado. USA	7.6	27.0 abc	5.1 ab	32.1 bcd
Early Yellow Premium	Sunseeds, USA	6.3	18.0 bc	6.7 ab	24.7 cd
Early Lockyer Brown	Yates, Australia	5.2	13.3 c	5.6 b	18.9 d

* = Control Cultivars
LSD (0.05) Large Bulbs = 16.20 t/ha
CV = 38.58%
Yield in each column followed by the same letter are not significantly different by DMRT (p=0.05).

Although the percent loss in dry weight during storage was greatest for large bulbs, they stored better than smaller ones. On the contrary, Karmarkar and Joshi (1941) and Tendaj and Rodkiewicz (1992) reported that small bulbs tend to loose water more quickly than large bulbs. However, in a review by Mondal and Paramanik (1992) a recommendation to use small bulbs suggests that they may be good keepers.

Marketable yields of onions obtained in the present trial are higher than those obtained in the screening

Daylength plays a very important role in the adaptation of onion cultivars, and is determined by both the time of year and latitude of the production area (Call 1986; Darley 1986).

In the lowlands of Central Province, Bull and Bourke (1983) and Bull (1985) were able to evaluate and release the cultivars Texas Early Grano, Yellow Granex and Red Creole. This indicates that 'long-day' and 'intermediate-day' cultivars bred for temperate regions (Australia, NZ and the USA) can be grown successfully under tropical lowland

TABLE 2: **Water Loss from Bulbs Stored for 8 Weeks**

Cultivar	Weight (kg)							
	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
Rio Enrique	4.43	3.41	3.39	3.39	3.37	3.36	3.34	3.33
Gladalan Brown	3.40	3.38	3.36	3.35	3.34	3.33	3.32	3.30
Tropic Brown	4.03	4.01	3.99	3.98	3.97	3.96	3.95	3.93
Superex	2.22	2.20	2.18	2.17	2.15	2.14	2.12	2.00
Dessex	3.38	3.36	3.34	3.33	3.31	3.29	3.26	3.24
Yellow Granex	3.39	3.37	3.35	3.34	3.33	3.32	3.31	3.29
Pira Ouro	2.26	2.24	2.22	2.19	2.17	1.98	1.97	1.96
Texas Early Grano	3.33	3.30	3.28	3.27	3.26	3.25	3.24	3.23
Rio Bravo	2.67	2.63	2.61	2.59	2.57	2.24	2.23	2.21
Early Yellow Premium	2.85	2.83	2.81	2.80	2.77	2.59	2.58	2.57
Early Lockyer Brown	3.23	3.20	3.18	3.17	3.16	3.14	3.12	3.11

TABLE 3: **Mean Monthly Temperatures Recorded at Laloki Research Station in 1993**

Month	Mean Minimum	Mean Maximum
January	27.5	32.9
February	26.5	32.7
March	27.3	32.9
April	26.9	32.6
May	26.3	32.3
June	26.0	32.4
July	24.7	31.7
August	19.7	31.7
September	22.3	32.4
October	24.1	32.9
November	25.8	31.8
December	24.3	32.9

PLATE 1: **Harvesting Onions at Laloki in September, 1993**

PLATE 2: **Marketable Bulbs of Cultivar Rio Enrique**

conditions at Laloki, Central Province.
Onions grown under different latitudes and seasons have had to adapt to changing daylength and temperatures, the two most important factors responsible for bulbing. The bulbing process is triggered by a critical minimum daylength, which may vary from 12 to 13 hours for 'short-day' types to 16 hours for extremely 'long-day' types (Darley 1986). Thus, onion cultivars can be classified into 'long-day', 'intermediate-day' and 'short-day' types depending on their bulbing response to daylength.

Probably of more significance under short-day tropical conditions is the effect of temperature on the physiological development and bulbing of onions. It is generally accepted that in the temperate regions, daylength is the primary factor in bulb initiation and that the role of temperature only enhances or delays the bulbing process (Heath 1945; Call 1986; Sinclair 1989). Brester (1989) showed that bulb development is accelerated by an increase in temperature. In the tropics and sub-tropics, seasonal variation in daylength is small but average temperatures are often high (Abdalla 1967; Bourke 1983). Fluctuations in daily mean minimum and mean maximum temperatures throughout the duration of the trial (June to September) ranged from 19.7° C to 32.4° C (Table 3).

The role of temperature in bulb development of onions was studied by Abdalla (1967) and Heath (1945). Temperature was considered by Abdalla (1967) to have a catalytic effect on onion bulbing. Heath (1945) found that higher temperatures (16-27° C) enhanced bulbing and that lower temperatures delayed bulbing. Higher temperatures reduce the minimum daylength required for bulbing to commence (Sinclair 1989), but quantitative differences among cultivars in their tendency to commence bulbing are dependent on the combined effect of photoperiod and temperature (Abdalla 1967).

Furthermore, high temperatures may retard physiological processes including cell enlargement at the leaf bases of onion and carbohydrate translocation; they may also initiate a change from cell division to cell expansion at the leaf bases through a hormonal mechanism (Abdalla 1967). This mechanism explains why onions form bulbs more quickly and mature early at high temperatures (Grodel and Gunther 1985; Call 1986; Sinclair 1989; Brewster 1990; Culley 1993).

Other cultural practices such as planting density, soil moisture regime, nutrient supply, time and depth of planting affect bulb formation and characteristics (Call 1986; Sinclair 1989; Brewster 1990).

All the cultivars used in this trial (Table 1) are 'long-day' and 'intermediate-day' types with the exception of cultivar Superex, a 'short-day' type from Takii Seeds, Japan. Therefore, it is highly likely that temperature, other than daylength, is responsible for the adaptation of these cultivars under short-day tropical conditions at Laloki, Central Province. The yields reported in this trial are comparable to those obtained by Culley (1993) for a direct sown crop under sub-tropical conditions in the Lockyer Valley (27°S), South East Queensland. Other commercial yields under Australian conditions are given by Rogers (1977). Under small-holder management conditions in PNG, yields of 20 t/ha are possible (Wiles 1992); there are lower than the average yield of 29 t/ha obtained in the present trial.

In the lowlands of Central Province, the time of sowing is very important as reported by Bull and Bourke (1983), Bull (1985), and Wiles (1992). The most suitable time of sowing is from February to June, although some cultivars may be suitable for a later planting (July to August). Observations from a field planting at Laloki in August 1993 showed some promising cultivars - YHO37, Tropic Ace, Haemek, Aldobo, YHO34 and Hojem (Sowei, unpublished). However, these cultivars should be further tested. Yields of an early season crop (February to March planting) could be maintained with adequate spraying to control purple blotch, a serious problem during the wet season.

Short day-length and high temperatures experienced during the dry season tend to promote premature bulbing of the seedlings in the seed-bed. Premature bulb formation in the seed-beds was particularly evident in the low-yielding cultivars Early Lockyer Brown and Early Yellow Premium. The critical daylength enhanced by high temperatures was probably responsible for the rapid bulb development and early maturity of cultivar Early Lockyer Brown. It was evident at transplanting that some of the seedlings had formed bulbs in the seed-bed. Selective transplants were used but bulbs developed rapidly. Hence, maturity was also very early. Cultivar Early Yellow Premium is probably not suitable for late planting (May to June).

Preventative spraying with fungicides (Benlate (R) and Dithane (R)) at recommended rates was able to

control purple blotch. However, it was observed that cultivars with dark green waxed leaves had more resistance than those with light green non-waxy leaves to purple blotch. For example, the cultivars Rio Enrique, Pira Ouro and Gladalan Brown had more tolerance to the disease than Superex. Currah and Proctor (1990) reported that some onions bred in Brazil (Baia Periforme group) have characteristic waxy dark green leaves and can tolerate pink root rot *(Pyrenochaeta terrestris)* and purple blotch. Cultivar Pira Ouro was developed by onion breeding at the University of Sao Paulo for the tropical north-east region of Brazil. The Pira series were derived from Baia Periforme lines which have a high dry-matter content (Currah Proctor 1990). This is consistent with the high dry-matter and good keeping quality of Pira Ouro reported in this trial.

There were also differences in the bulbing habit. The cultivars Superex, Early Lockyer Brown, Early Yellow Premium and Dessex formed bulbs earlier than the other early bulbing types, whereas Pira Ouro and Gladalan Brown formed bulbs late in this trial. The extended length of the growth period meant bigger plants and subsequently a larger bulb size. This is probably why cultivar Rio Enrique produced more large bulbs than small bulbs (Table 1 and Plate 2).

It was reported by Grodel and Gunther (1985) that cultivars Early Lockyer Brown and Early Lockyer White formed bulbs in the seed-bed at Kuk (1550 m). However, Wiles (1991, unpublished) found that these cultivars had satisfactory yields at Tambul (2240 m). The cooler temperatures at Tambul (8.5^{0}C - 19.0^{0}C) could have lengthened the growing period for bulb development and maturity. Similar results were obtained by Culley (1993), from a direct sown crop, while evaluating a range of 'short-day' hybrids including Early Lockyer White for production in the Lockyer Valley (27^0 S), South East Queensland, Australia.

CONCLUSIONS

Yields obtained in this 'elite' cultivar trial have indicated that suitable hybrids from Australia, New Zealand and the United States can be grown successfully under tropical conditions in the lowlands of Central Province, PNG.

Seven cultivars, Rio Enrique, Tropic Brown, Dessex, Yellow Granex, Pira Ouro, Texas Early Grano and Rio Bravo have been selected, which should be promoted to the growers in the lowlands of Central Province. This program needs to be extended to other potential production areas such as Tapini in the Central Province and Kainantu in the Eastern Highlands Province with a relatively good market access. It is anticipated that this program will promote commercial onion production to eventually replace imported onions on the domestic market.

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REFERENCES

ABDALLA, A.A. (1967). Effect of temperature and photoperiod on bulbing of the common onion (*Allium cepa* L.) under arid tropical conditions of sudan. *Experimental Agriculture* **3**: 137-142.

ABDALLA, A.A. and Mann, L.K. (1963). Bulb development in onion *(Allium cepa)* and the effect of storage temperature on bulb rest. *Hilgardia* **35** (5): 85-112.

AUSTIN, R.B. (1972). Bulb formation in onions as affected by photoperiod and spectral quality of light. *Journal of Horticultural Science* **47**: 493-504.

BOURKE, R.M. (1983). Growing introduced vegetables in the lowlands 1. The lowlands environment. *Harvest* **9**(2): 63-67.

BREWSTER, J.L. (1990). The influence of cultural and environmental factors on the time of maturity of bulb onion crops. *Acta Horticultural* **267**: 289-296.

BULL, P.B. and BOURKE, R.M. (1983). Growing vegetables in the lowlands 2. Fruits, vegetables, corn, bulb and root vegetables. *Harvest* **9**(2): 68-73.

BULL, P.B. (1985). Horticulture Note No. 7. Vegetable variety recommendations for the Port Moresby Lowlands. *Harvest* **11**(1): 43-45.

CALL, E.J. (1986). Factors affecting bulbing response in onions. *Australian Onion Grower* **3**: 18-19.

CULLEY, A. (1993). Boosting onions in Queensland. *Good Fruit and*

Vegetables **4**(4): 35.

CURRAH. L. and PROCTOR, F.J. (1990). Onions in tropical regions. *Natural Resources Institute Bulletin* No. 35. 232 pp.

DARLEY, E. (1986). Adaptability of onion varieties. *Australian Onion Grower* **3**: 12-13.

GOMEZ, K.A. and GOMEZ, A.A. (1984). Statistical Procedures for Agricultural Research. (Second edition). John Wiley & Sons, New York, N.Y.

GRODEL, E. and GUNTHER, M. (1985). Vegetable varieties for the Highlands of Papua New Guinea, Kuk Information Bulletin No. 1 (Mimeographed).

GUNTHER, M. (1985). Horticulture Note No. 9. Vegetable Variety Recommendations for the Highlands of Papua New Guinea. DPI Publications Section, Konedobu.

HEATH, O.V.S. (1945). Formative effects of environmental factors as exemplified in the development of the onion plant. *Nature* **155:** 623-626.

JAYABHARATHI, M. (1989). Influence of different doses of N, P and K on the yield and quality of aggregatum onion cv. Co. 4 *Madras Agricultural Journal* **76**(3): 150-155.

KARMARKAR, D.V. and JOSHI, B.M. (1941). Investigations on the storage of onions. *Indian Journal of Agricultural Science* **11**: 82-94.

KURIKA, L., SOWEI, J.W. and OVIA, K. (1992). Onion variety trial. Laloki Agricultural Research Station Report (Mimeographed).

MONDAL, M.F. and PARAMANIK, M.H.R. (1992). Major factors affecting the storage life of onion - a review. *International Journal of Tropical Agriculture* 10(2): 140-146.

MSTAT Version 4.0. (1987). Michigan State University.

PITT, A.J. (1988 a). Production of Bulb Onions. Horticulture Note (no original data) (Mimeographed).

ROGERS, I. (1977). Commercial onion growing. Bulletin 7/77. Department of Agriculture and Fisheries, South Australia.

SINCLAIR, P. (1989). Physiology of the onion. *Australian Onion Grower* **6**:7-9.

SOWEI, J.W. (1993). Onion variety screening trial. Laloki Agricultural Research Station Report (Mimeographed).

STOW, J.R. (1975). Effects of humidity on losses of bulb onion (Allium cepa) stored at high temperature. *Experimental Agriculture* **11**: 81-87.

TENDAJ, M. and RODKIEWICZ, T. (1992). Effect of fertilization with nitrogen and potassium on storage losses of onion sets. *Biuletyn Warzywniczy* **39**: 81-92.

WILES, G.C. (1991). Report on a strategy for achieving self sufficiency in bulb onion production in Papua New Guinea. (Mimeographed).

WILES, G.C. (1992). Production of Bulb Onions. Horticulture Note No. 12. *Harvest* **14**(1-2):25-28.

WILES, G.C. (1992). Harvesting, storage and marketing of bulb onions. Horticulture Note No. 15. *Harvest* **14**(1-2): 29-30.