NUTRITIONAL FACTORS INFLUENCING THE YIELD OF BUCKWHEAT IN THE NEW ENGLAND TABLELANDS

BY

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PREFACE

I certify that the substance of this thesis has not already been submitted for any degree and is not currently being submitted for any other degree.

I certify that to the best of my knowledge any help received in preparing this thesis, and all sources used, have been acknowledged in this thesis.

[redacted]
Muzammil Shah

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ABSTRACT

Buckwheat (*Fagopyrum esculentum* Moench) belongs to the family *Polygonaceae*. Although it is not a member of the grass family Poaceae, (Hughes and Metcalfe, 1972; Martin *et al.,* 1976: Taylor, 1996), it is considered as a pseudocereal (Hughes and Metcalfe, 1972) and as a nutraceutical (DeFelice, 1994). The most appealing quality of this crop is its high nutritional value, which contains protein of very high biological value (Eggum, 1980; Javornik, 1980). Buckwheat grain is used in many ways for human use throughout the world. Buckwheat, native to temperate east Asia, where it was grown in China before 1000 AD (Robinson, 1980), has proven itself to be widely adopted around the world. It is of economic importance in many countries including Nepal, India, Iran, Pakistan, Afghanistan, China, Japan, Korea, Russia, Poland, Hungary, Yugoslavia, Canada, United States, and Brazil (Mazza, 1986). Research demonstrating the many health benefits of buckwheat consumption is impressively large while research related to the nutritional requirements of buckwheat as related to soil type is lacking in many parts of the world.

A series of experiments were conducted in the field and glasshouse to investigate the nutritional requirements of buckwheat as related to soil types. The potentially suitable areas for the cultivation of buckwheat in the New England Tablelands were identified and mapped (Map 3.7) during the current research program. These areas were classified as climatically and topographically suitable for the successful cultivation of buckwheat.

An experiment was conducted to visually identify the deficiency symptoms of buckwheat as no published or unpublished data were available. The omission of nutrients in the triple-pot technique as described by Bouma (1966), Janssen (1974, 1990) and Muller *et al.*, (1979) was used. Distinctive deficiency symptoms due to omission of nitrogen (N), phosphorus (P), potassium (K), and sulfur (S) were identified, which were mostly similar to the deficiency symptoms of other plants recorded and described by Thompson and Troeh (1975), Tisdale *et al.*, (1993), Grundon (1987), and Bergmann (1992). The same technique of the nutrient omission was used for evaluating the nutrient status of five agriculturally important soils of this region using buckwheat as a test crop. This investigation revealed that the omission of N, P, and S from the nutrient solution decreased the dry matter yields significantly. The omission of K from the nutrient solution did not show any significant effect on the dry matter yields except the grey brown podsolic, Uralla soil, which contained only 0.1 meq/100g of K. The available levels of calcium (Ca), magnesium (Mg) are currently sufficient in all soils.

The micronutrients response indicated that almost all the soils were sufficient in these nutrients for the yield of buckwheat.

A study was conducted to determine the effectiveness of various fertiliser sources of the major elements including urea, $(NH_4)_2SO_4$ and NH_4NO_3 for N, PARP, RP, SSP, and TSP for P, K_2SO_4 and KCl, for K, and K_2SO_4, ES, $CaSO_4$, $(NH_4)_2SO_4$ for S were used. On the average, straw yield increased by 49, 50, 59, 45% and grain yield by 25, 26, 22, and 30% over control with the sources of N, P, K, and S, respectively in nutrient rich, chocolate soils. However, in the nutrient deficient grey brown podsolic soils these increases were 271, 218, 262, and 271% for straw and 191, 149, 217, and 195% for grain, with the respective sources of N, P, K, and S fertilisers. Nitrogen and K sources were similar in efficiency on both the soils tested. For the sources of P and S on the light clay soil, triple-super phosphate, partially acidulated rock phosphate and rock phosphate showed similar efficiencies and elemental sulfur (ES) proved the best source for the satisfactory grain yield of buckwheat. Single-super phosphate and gypsum gave the best results for the grain yield for a sandy loam, grey brown podsolic soil.

The effects of micronutrients zinc (Zn), copper (Cu), boron (B), and molybdenum (Mo) applied at the rate of 5 kg/ha each in a pot experiment on a chocolate and grey brown podsolic soils showed no beneficial effects indicating that adequate levels of all these nutrients are currently present. Boron application showed depressing effects on most of the plant parameters measured while other nutrients did not cause any significant increase in the plant parameters in most cases when compared with the control. Addition of Cu as Cu x Zn and Cu x B tended to stimulate the straw and grain yields. Similarly, Mo x Zn showed additive effect on yield.

Major nutrients (N, P, K, and S) were applied at the rate of 50, 40, 50, and 50 kg/ha, respectively to buckwheat on a yellow podsolic and a chocolate soil under field conditions. The results from the yellow podsolic soil indicated that it was deficient in N, P, and S. Addition of 50 kg/ha N produced significant increases of 121 and 136% in straw and grain yield over control in the grey brown podsolic soil. The straw yield increased by 155, 155, 180 and 197% with NP, SKN, SN, and KNP, respectively. Similar effect was observed for grain yield. This suggested that combined application of SN and that of NPK were more beneficial in terms of buckwheat production on yellow podsolic soil. The application of K was not beneficial except when applied in combination with N and P. The nutrient rich chocolate soil showed no response to the application of any nutrient applied except N which caused non-significant increases of 26 and 21% in straw and grain yield respectively. The combined application of NP did not improve the straw and grain yield as compared to N alone but the combine application of KNP and SNP improved the yield enhancement by 37% as compared to control. This indicated that chocolate soil was currently adequate in the major nutrients. These results are in agreement with Murayama *et al.*, (1998), and Goos *et al.*, (1998).

Buckwheat is reported as a heavy user of phosphorus (P) and had given consistent increases in yield with P applications. Three sources of P i.e. partially acidulated rock phosphate (PARP), phosphate rock (PR), and triple-super phosphate (TSP) were applied at the rate of 0, 10, 40, and 80 kg P/ha to two P-deficient soils with an initial P availability of 9 and 6 mg/kg Colwell P. A reverse dilution technique was used (Shedley *et al.*, 1979) and the soil was labelled with radioactive phosphorus ^{32}P (half-life of 14.7 days) as KH_2PO_4. Nitrogen, phosphorus and potassium were applied at the rate of 61, 50, and 50 kg/ha, respectively. The results indicated that the dry matter yield at maturity for Coventry soil as affected by the sources was ranked as TSP > PARP = PR and the P contribution in the plant was in the order of TSP > PARP > PR. In Kirby soil, the dry matter yield affected by sources was ranked as TSP > PARP > PR, while P contribution from these sources was in the order of TSP > PARP = PR.

It can be concluded from these studies that chocolate soil, containing adequate nutrients, offers great promise for buckwheat cultivation. All other soils tested (grey brown podsolic, yellow podsolic, and black earth) will need addition of N, P, and S for obtaining optimum yield. Further research is needed to establish appropriate levels of these nutrients for cultivation of buckwheat on these soils.

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