PRACTICAL ALTERNATIVE PRODUCTION PRACTICES FOR POTATO

by
Thomas F. Cummings and Robert E. Thornton
Washington State University
Dept. Horticulture and LA

The success of modern agriculture relies mainly upon improved plant breeding, mechanization, and high inputs of fertilizers and pesticides. This is especially true in Washington State, where high production and record yields (500+ cwt/acre) have been obtained (28).

The benefits of high chemical usage on potatoes, however, can have drawbacks. These drawbacks are the significant cost of chemical inputs, pest resistance, agriculturally associated environmental problems and consumer attitudes about chemical use. These and other concerns such as soil loss and socio-economic disruption of family farms has led recently to interest in alternative agricultural systems employing cultural practices that may diminish these concerns. These alternative systems are known variously as organic, low input, sustainable, and are usually contrasted with conventional agricultural systems.

During the past two years, we have been investigating cultural practices on potatoes that differ from conventional or mainstream practices used in a typical growing operation. The growers in the study using these practices were all competent, experienced, and economically dependent on their agricultural endeavors.

An alternative cultural practice in this study is defined as a practice different from a common or conventional production practice used on potatoes. This definition does not assume that an alternative practice is 'better' or more correct than a conventional practice, but only different. Alternative production practices should be considered when their incorporation into a potato growing operation results in a significant improvement in the economic, horticultural, social, or environmental condition of the farm or community. Therefore alternative cultural practices can not be considered practical if using these practices result in the loss of a farm's economic viability through excessive costs or a poor crop.

The alternative practices used by growers in this study were practical for their potato operations. Whether these alternative practices are practical in whole, part, or not at all, will depend on the individual growing operation.

This Presentation is part of the Proceedings of the 1994 Washington State Potato Conference & Trade Fair.

VARIETY SELECTION

Most of the commercial potato operations in Washington State tend to grow one or two russet varieties mostly for processing. This practice has led to a large successful industry resulting in a strong economic base for associated farms and communities. Growing several types of potato varieties for different markets in Washington could be considered an alternative practice for a potato operation. The growers in the study who use this practice benefit by:

1) using a cultural practice that reduces the incidence of pest, and 2) gaining an economic market advantage.

It is a well known biological principle that a diverse population of plants can escape pest and disease more readily than plants sharing the same gene pool as in a monoculture system. Unless high-input cultural practices are used, serious epidemics and yield loss may occur when a single potato variety is extensively grown. Surveys of the alternative growers reveal that they will readily replace a variety that gives either significant disease or quality problems, rather than increase inputs or significantly alter cultural practices. It should be noted that these growers are more involved in the wholesaling and marketing of their produce than most potato growers, and therefore can be flexible in this practice. It would be difficult for many growers however, to readily change potato varieties, especially when under specific production contracts.

Growers in this study who grew several varieties were able to take advantage of premium prices paid for popular varieties, and were less likely to be tied economically to one variety. These growers also used closer plant spacing and earlier harvest on some varieties, a practice that can produce smaller tubers and less yield, but can be economically advantageous. Early harvest for fresh market may result in a higher wholesale market return and lower costs for pesticides and fertilizers. The early harvest could also be followed by a cover or fall horticultural crop. Smaller tubers ('B' and 'C') on the fresh market can be an economic advantage as shown by the wholesale price paid to growers for 50 lb. cartons of red potatoes (25, 26):

Nov. 1992		Nov. 1993	
'A'	$9.50	'A'	$9.00
'B'	$15.50	'B'	$14.00
'C'	$22.00	'C'	$21.00

Source: Northwest Vegetable Report/Federal State Market News.

It is important to state that these market niches can be saturated quickly and that even though the varietal potato market has increased, it would not be feasible for most growers to enter these markets, unless the markets are expanded.

A decision on whether to grow a new variety of potato can be assisted by reviewing the articles "Deciding if a New Potato Variety is Suitable for Your Operation" and "Customizing Management Strategies for New Potato Varieties" by Stephen L. Love (12, 13).

WEED CONTROL

Until the advent of herbicides for weed control, mechanical and manual cultivation was the conventional method for controlling weeds in potatoes. Manual weed control in potatoes is not a practical alternative practice for most potato operations. The fields that used this method of weed control in this study needed an extra 3 to 4 man hours/acre for weed control. The use of this method would only be practical for small production operations. Some growers still use mechanical cultivations as the mainstay for weed control in potatoes. In the study growers who relied solely on cultivations for weed control needed from none to four extra post plant cultivations compared to growers who used herbicides. Approximate cost of one cultivation operation (6-$13/A) or an herbicide application (10-$25/A) can vary greatly. The advantage in time and expense of using herbicides is obvious compared to a situation where several extra cultivations for weed control is warranted.

Comparing weed control practices however is difficult since many factors are involved in the outcome other than specific method.

Probably the best weed control is a quick emerging, healthy potato canopy which can out compete weeds for light and nutrients. The grower can't always influence optimum plant growth, especially during adverse environmental conditions. The study showed early cool weather during the 1993 potato growing season delayed canopy growth which increased weed competition and herbicide use compared to the more favorable 1992 growing season.

Other factors suggested by the study that influenced weed control in potatoes were planting date, methods and timing of cultivations, weed species, and previous cropping practices.

Early emerging weeds may be cultivated if potato planting is delayed, reducing weed germination during canopy growth. Delayed planting may also result in faster canopy emergence due to warmer temperatures. The negative side of delaying crop planting is a shorter growing season and loss of early market opportunities.

Rotation strategies are important for weed control in potatoes. Potatoes following a cover or horticultural crop may have less weed problems than following fallow ground or pasture. It is not always practical to determine rotation strategies based solely on weed control.

The study made evident that controlling weeds in potatoes is a complicated process requiring much consideration and should go beyond label recommendations or calendar cultivations.

FERTILITY

The main alternative practice for supplying nutrients to a potato crop by the growers in this study is the use of animal manures or compost. Manures and compost used as organic soil amendments can benefit a potato growing operation by:

- Decreasing soil compaction; increasing soil friability (10, 22).
- Increasing water retention and soil infiltration (22).
- Increasing microbiotic activity, which makes available essential plant nutrients and may suppress harmful pathogens (8, 9, 15).
- Providing a complete nutrient base (N.P.K. and micronutrients) (6, 14, 20).
- Slow release of nutrients over the growing season. (1, 2, 3).

It is evident from this study that using manures in a potato growing operation can have these drawbacks:

- Knowing how much nutrient is available to a crop.
- Moving and incorporating the large amounts of manure required for adequate nutrient and organic benefit.

Animal manure nutrient values can differ dramatically depending upon the type of animal and the animals feed. Nutrient values also depend upon how the manure is stored, handled, as well as the timing and method of incorporation (2, 3, 24). Due to this wide variability, application rates suggested in the literature may not be reliable. To receive the most benefit from manure or compost, the material should be analyzed. Timely application and incorporation of manure is also important since much of the manure nitrogen can be lost due mostly to escape as gaseous ammonia.

Initially, only part of the nitrogen is available to a potato crop as nitrate or ammonia; the rest is in an organic form that is mineralized later. This characteristic slow release of organic matter can be a benefit to crops later in the season. The phosphorus in manure has low solubility and also may not be available initially in the amounts needed (2). Therefore, nutrient amendments may be warranted for early tuber demands. Similar to any fertility program, using manures requires knowing the nutrient value of the materials used, soil testing, and knowledge of the amount of nutrients needed for the specific potato crop.

The major nutrients supplied to three potato growing operations in the study by different manures are shown in Table 1. The nutrient amounts listed in the table were available to the potato crop during the growing season the manure was applied.

Table 1 shows a value for potassium from the hen/layer manure that is lower than typically applied to a potato crop. This shows the importance of nutrient testing when using organic matter for crop fertility. Hen/layer manure typically has more ammonium nitrogen available than fryer/litter manure. This would give the potato crop an early and readily available form of nitrogen from the hen/layer manure compared to the fryer/litter or dairy manure. Like any fertility program, using manures requires knowing the nutrient value of materials used, soil testing, and knowledge of the amounts of nutrients needed for the specific potato crop.

The other problem with the use of manures is the large bulk that must be handled. The growers in this study typically use 5-10 tons/acre of manure on potatoes (approx. 10-20+ cubic yds./acre). Although manure may be cheap, a major cost of using it is hauling it to the farm and applying it to the field. Thus, economic and practical utilization of manure requires having a reliable source within a reasonable distance to the potato growing operation, and loading, spreading, and incorporating it in an economical and timely manner. Comparisons of costs and application times of manure on three different potato operations in the study are shown in Table 2. The material costs of the manure are economically attractive, but the fixed and variable costs reflect the expense of applying the large amounts of bulk organic matter. The total costs of applying manures for fertility to a potato crop may be advantageous compared to a conventional fertility operation, but time of application for organic material may not be practical. With the application of manure requiring a low of 30 min./A for 10 T/A of wet chicken manure to a high of 60 min./A for 5 T/A of dry chicken manure (Table 2), a large potato growing operation may not be able to supply all the manure needed to a crop in a timely procedure before planting. The potato operation receiving the dairy manure was at an advantage however since the dairy operation applied the manure free in the fall before potatoes.

The use of bulk manure/compost amendments may not be a practical alternative at this time to all growers due to availability of manures, machinery, and time. However, an excess of animal manures exists in certain regions. Urban areas are collecting and composting yard waste on a large scale and private entrepreneurs are starting composting operations. This backlog of nutrient-rich, organic matter may form a market condition that will be advantageous to a potato grower in the future.

GREEN MANURE

Currently there is increased interest in the use of green manure crops in agriculture. Green manures can be an asset to a potato growing operation in several ways:

- Planting a green manure crop in a rotation before or after a potato crop can tie up nitrogen in the soil and prevent leaching (21, 27).

- Erosion from rain or wind especially in the winter or early spring can be reduced by a cover crop such as a green manure (17).

- By incorporating a green manure crop into the soil, the following potato crop can benefit from the added organic matter. The benefits to a potato crop from the added organic matter include increased soil friability, reduced compaction, and improved water retention.

- A green manure crop before potatoes increases soil microflora and may assist in the control of certain potato pathogens. The control of nematodes and verticillium wilt (7, 19), and the reduction of common scab on tubers (16, 18) by certain green manure crops has been shown.

- A substantial weed control benefit may result from a green manure crop which was suggested in the study and shown in the literature (4, 5, 11).

The main benefit from a green manure crop is the release of nutrients to the potato crop after plow down. Nutrients from the decomposition of the green manure crop tend to be released over time and their availability is dependent on temperature and moisture. The amount of nitrogen and organic matter available to a potato crop after spring plow down depends on the type and amount (biomass) of green manure produced. Usually a legume is selected as a green manure since it can provide additional nitrogen to the potato crop and tends to break down quicker than grass green manure crops.

Some of the growers in the study use or have used green manures before potatoes, either winter rye, Austrian winter peas, or a combination of the two. Nitrogen fixing winter peas may add 84-155 lbs. of nitrogen/acre. Other legumes (hairy vetch, alfalfas, red clover) can fix substantially more nitrogen, and some tend to be more winter hardy than Austrian winter peas (17, 23).

The growers showed an out of pocket cost of approximately $17/A to $58/A for establishing a green manure crop. The cost of establishing a green manure crop can vary substantially depending on method, type and amount of seed.

The economic payback from planting a green manure crop may be more than just an increase in nutrients. It is difficult to determine however, an economic value for reduced leaching and erosion, improved soil structure and water retention, or disease and weed control on potatoes from a green manure crop.

SUMMARY

- Reduction of pest problems, lowering of inputs, and high returns can be the benefits resulting from establishing new potato varieties. Varietal markets are limited, however, and may not be profitable to all growers. A new variety may not be horticulturally suitable for a particular potato operation. The grower should research and weigh all aspects before establishing a new variety.

- Cultural practices and environmental conditions can influence weed growth in a potato growing operation. Good weed control can be accomplished by cultivation practices alone, or with herbicides. Timing of cultural operations, knowledge of weed species, field monitoring, and selection of rotations should also be considered as important weed control practices.

- Potato fertility can be supplied by manures and compost. Also, these materials can give organic benefits to the soil and crop such as improved soil structure and water retention, increased microbiotic activity, and gradual nutrient release. However, lack of local access to manures/compost and application problems due to physical bulk may make the use of these materials impractical for many potato growing operations. A backlog of nutrient rich organic matter may make the use of these amendments economically advantageous to more growers in the future.

- Green manures can add fertility to a potato crop by releasing nutrients after plow down. Other advantages of green manures include reduced leaching and erosion, improved soil characteristics, and possible disease and weed control.

Overall, the use of a green manure crop would seem to be the most practical alternative practice for including into a potato growing operation. The investment risk is minimal compared to establishing a new potato variety. Labor time is minimal in planting a green manure crop compared to extra cultivations for weed control or spreading bulk organic materials. Finally, unlike spreading bulk organic materials, no new or special machinery is required in establishing a green manure crop.

REFERENCES

1. Avnimelech, Y. 1986. Organic residues in modern agriculture. In: Y. Chen and Y. Avnimelech (ed.) The role of organic matter in modern agriculture. Martinus Nijhoff Publ., Dordrecht, Netherlands.

2. Beegle, Douglas, 1992. Introduction to manure management. Proceedings of the 1992 Northwest and Lower Columbia Dairy Shortcourses. O.S.U. and W.S.U., Blaine, Wa. Pp. 1-5.

3. Beegle, Douglas, 1992. Agronomic use of manure. Proceedings of the 1992 Northwest and Lower Columbia Dairy Shortcourses. O.S.U. and W.S.U., Blaine, Wa. Pp. 6-13.

4. Bell, C.E., and K.S. Mayberry. 1992. Effect of green manures on weed biomass. 1992 Res. Progress Rep. West. Soc. of Weed Science.

5. Boydston, R. 1993. Weed control in potatoes with green manure crops. 1993 Res. Progress Rep. West. Soc. of Weed Sci. VII-4.

6. Cook, G.W. 1977. The roles or organic manures and organic matter in managing soils for higher crop yields - A review of the experimental evidence. p. 53-64. In: Proc. Int. Seminar on Soil Environment and Fertility Management in Intensive Agriculture, Tokyo, Japan. Soc. of the Sci. of Soil and Manure.

7. Davis, J.R., O.C. Huisman, D.T. Westerman, S.L. Hafez, L.H. Sorensen, and A.T. Schneider, 1991. Cover crops and their effects on disease control and yield. Proceedings of the 30th annual Washington State Potato Conference, Moses Lake, Wa. Pp. 65-73.

8. Doran, J.W., D.G. Fraser, M.N. Culik, and W.C. Liebhardt. 1988. Influence of alternative and conventional agricultural management on soil microbial processes and nitrogen availability. Am. J. of Alternative Agric. 2(3): 99-106.

9. Fraser, D.G., J.W. Doran, W.W. Sahs, and G.W. Lesoing. 1988. J. Environ. Qual. 17:585-599.

10. Hafez, A. A. R. 1974. Comparative changes in soil-physical properties induced by admixtures of animal manures from various domestic animals. Soil science. 118:53-59.

11. Ilnicki, R.D., and A. J. Enache. 1992. Subterranean clover living mulch: an alternative method of weed control. Agric., Ecosystems and Environ. 40:249-264.

12. Love, S. L. 1993. Deciding if a new potato variety is suitable for your operation. Proceedings of the 32nd annual Washington State Potato Conference, Moses Lake, Wa. Pp 47-50.

13. Love, S. L. 1993. Customizing management strategies for new potato varieties. Proceedings of the 32nd annual Washington State Potato Conference, Moses Lake, Wa. Pp 73-78.

14. Maine Agricultural Experiment Station. 1949. Green manure crops and rotations for Maine potato soils. Bull. No. 474.

15. Martyniuk, S., and G.H. Wagner. 1978. Quantitative and qualitative examination of soil microflora associated with different management systems. Soil Sci. 125(6):343-350.

16. Millard, W.A. 1927. Antagonism of micro-organisms as the controlling factor in the inhibition of scab by green manuring. Ann. Appl. Biol. 14:202-216.

17. Morrison, K.J. 1992 (revised). Green Manure and Cover Crops for Irrigated Land. Washington State University Extension Bulletin EB0489.

18. Rogers, P.F. 1968. Organic manuring for potato scab control and its relation to soil manganese. Ann. Appl. Biol. 63:371-378.

19. Santo, G. S., H. Mojtahedi, A.N. Hang, and J.H. Wilson. 1991. Control of the Columbia root-knot nematode using rapeseed and sudangrass green manure. Proceedings of the 30th annual Washington State Potato Conference, Moses Lake, Wa. Pp. 41-46.

20. Sharma, R. C., P.M. Govindakrishnan, R.P. Singh, and H.C. Sharma. 1988. Effects of farmyard manure and green manure on crop yields and nitrogen needs of potato-based cropping systems in Punjab. J. Agric. Sci. 110:499-504.

21. Shipley, P.R., J.J. Meisinger, and A.M. Decker. 1992. Conserving residual corn fertilizer nitrogen with winter cover crops. Agron. J. 84:869-876.

22. Sojka, R.E. 1993. Soil compaction. p.194-198. In: Proceedings of the Winter Commodity Schools, 1993, Pocatello, Id. Univ. of Idaho Coop. Ext. System, Moscow, Id.

23. Stevens, R.G., 1992. SARE Annual Report, unpublished. Extension Soil Scientist, IAREC, W.S.U., Prosser, Wa. 99350.

24. USDA. Fact Sheet: Animal manure for crop production. AFS 4-5-3 USDA. U.S. Gov. Print. Office, Washington D.C.

25. USDA/Washington Dept. Agriculture. 1992. Northwest Vegetable Report. Federal-State Market News.

26. USDA/Washington Dept. Agriculture. 1993. Northwest Vegetable Report. Federal-State Market News.

27. Vereijken, P. 1989. Research on integrated arable farming and organic mixed farming in the Netherlands. p. 287-296. In: C.A. Edwards, Rattan Lal, P. Madden, R.H. Miller, and Gartbuse (ed.) Sustainable agricultural systems. Soil and Water Conservation Soc., Ankeny, Iowa.

28. Washington Agricultural Statistics Service. 1993. Washington agricultural statistics, 1992-1993. Olympia, Wa.

29. Zublena, J.P., J.C. Barker, and T.A. Carter. 1990. Soil facts: Poultry manure as a fertilizer source. North Carolina Agric. Ext. Service, Raleigh, N.C.

Table 1. Comparison of available major nutrients[1] of manure types for three potato growing operations; 1992 & 1993.

Type Manure	Nitrogen lb/A	Phosphorus lb/A (P_2O_5)	Potassium lb/A (K_2O)
Chicken, fryer/litter 5 Ton/A, dry[2]	180	224	144
Chicken, hen/layer 10 Ton/A, wet[2]	162	225	75
Dairy, solid Dairy, liquid 5 Ton/A[3]	50 14	20 6.5	40 12.5

[1] Micronutrients also supplied: B, Ca, Cu, Fe, Mg, Mn, Mo, S, Zn.
[2] Source: Zublena et al., 1990.
[3] Source: Beegle, 1992.

Table 2. Comparison of costs and application times of manure types for three potato production operations; 1992 & 1993.

Type Manure	Application Time/A	Manure Cost/A	Variable Cost/A	Total Cost/A
Chicken, Fryer 5 Ton/A, Dry	45 - 60 min. 10' Spreader	$37	$62	$76
Chicken, Hen 10 Ton/A, Wet	30 - 45 min. 30' Spreader	Free	$32	$52
Dairy, Liquid 5 Ton/A	?	Free	Free	Free