Effects of Mefluidide, a Plant Growth Regulator, on Plant Development, Processing Quality, and Storage of Potatoes [Solanum tuberosum L.].

by

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EFFECTS OF MEFLUIDIDE, A PLANT GROWTH REGULATOR, ON PLANT DEVELOPMENT, PROCESSING QUALITY, AND STORAGE OF POTATOES (SOLANUM TUBEROSUM L.)

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A thesis submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements of the degree of

MASTER OF SCIENCE

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ABSTRACT

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Field, storage, and growth room experiments were conducted to examine the effects of foliar-applied mefluidide {N-[2,4-dimethyl-5[[(trifluoromethyl)sulfonyl] amino]phenyl]acetamide} on yield, plant development, processing quality, and storage of potato [Solanum tuberosum L.] cultivars Russet Burbank and Norchip.

Mefluidide had little or no effect on yield except in 1983 when marketable yields of Russet Burbank were reduced considerably. Preharvest sucrose content was slightly higher in mefluidide-treated Norchip potatoes but during the storage season there were no marked differences between treatments. The sucrose content of Russet Burbank increased with the concentration of mefluidide and remained higher for the duration of storage. In the mefluidide treated potatoes the respiration rates were increased anywhere from 10 to 50% at the 2.00 kg ai/ha rate and weight loss about 20-100% more than the control. The majority of the additional weight loss was not due to increased respiration but to water loss with respiration accounting for 2.8-5.3% of the total weight loss. When Russet Burbank potatoes were treated with mefluidide on two different dates, the later treatment tended to increase the sucrose content, rate of respiration, and the weight loss. The field study also showed that

the potato periderm darkened and became more russetted with mefluidide treatments.

Growth room studies indicated a possible reduction in fresh weight, dry weight, and dry weight percentage of potato tubers with mefluidide treatment. Limited scanning electron microscopic work showed that there is a possibility of an affect of mefluidide on the structure of the periderm which in turn could effect the permeability of the periderm and increase water loss.

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Chapter I

INTRODUCTION

In Manitoba approximately 16,000 hectares of potatoes are grown every year and of this production 80% are directed towards processing, ie. chipping, french fries, and dehydration. A requirement of the potato processing industry is to develop methods or techniques in order to increase and improve yield, processing quality, and storage capabilities of potatoes [*Solanum tuberosum* L.]. Quality of processing potatoes is improved by an enhanced chemical maturity, mainly by a low sugar content and a high specific gravity. A low sugar content, namely reducing sugars, results in a higher quality chip or french fry by yielding a light colored product. A high specific gravity affects quality and quantity of the end product due to a higher dry matter content.

Improved storage capabilities of potatoes is also necessitated by the industry in order to maintain quality and reduce storage losses. Weight loss can be anywhere from 4-17% during a normal storage period and of this 10% is considered to be respiratory loss and the remaining 90% is evaporative or water loss. Hence, an enhanced maturity of the potato can reduce these losses by either a lower metabolic activity in storage or better periderm development to reduce water loss. Sucrose content of the potato is also used as an indicator of the longevity of storage and the quality of the processed product after the potatoes are lifted from storage.

To this end mefluidide {N-[2,4-dimethyl-5-[[(trifluoromethyl) sulfonyl] amino]phenyl]acetamide}, a plant growth retardant, was used and investigated for any sign of promise in enhancing any of the qualities mentioned above. Previous studies on this subject were inconclusive but indicated that there may be some positive qualities of this regulator in enhancing specific gravities, chip color, and periderm development while having a negative impact on the chemical maturation (sucrose content) and weight loss.

In this investigation the effect of foliar-applied mefluidide was determined on the yield, specific gravity, chip color, the rate of respiration, sucrose content, and weight loss throughout the storage period on field grown potato cultivars Norchip and Russet Burbank. In addition the effect of applying mefluidide on two different dates was tested on Russet Burbank potatoes. Sucrose content was also determined on immature Norchip potatoes before harvest to observe any effect on the maturation process. Growth room studies were performed on Norchip potatoes to study the influence of mefluidide on plant growth, tuberization, dry matter accumulation and periderm development.

Chapter II

LITERATURE REVIEW

This review of the literature covers many of the areas previously covered in an earlier dissertation (Zulu, 1983), therefore, this will not be an exhaustive review but an attempt to briefly comment on the background of my research.

2.1 MEFLUIDIDE: A PLANT GROWTH REGULATOR

Mefluidide, while referred to as a synthetic growth regulator, is most often known as a growth retardant or a herbicide. The principle area of application of this chemical has been in the area of turf grass growth regulation since it can suppress growth and seed head production (Field and Whitford, 1980; Jackson et al., 1980). Turf grass growth can be suppressed for 6-8 weeks without adverse phytotoxicity. Mefluidide retarded shoot fresh weight, dry weight, and height of corn (*Zea mays* L.) and reduced chlorophyll content at the base of the leaves (Truelove et al., 1977). Mefluidide can also suppress vegetative growth in trees and woody ornamentals (Gates, 1975) and in sugar beets [*Beta vulgaris* L.] (Schweizer and Eshel, 1978).

The retardation capabilities of mefluidide allow it to have herbicidal attributes by suppressing selectively the growth of such weeds as johnsongrass [*Sorghum balepens* (L.) Pers.], hemp sesbania [*Sesbania exaltate* (Raf) Cory], and common cocklebur [*Xanthium pensylvanicum* Wallr.]

in crops such as soybeans [Glycine max (L.) Merr. 'Bragg'] (McWhorter and Barrentine, 1979). Mefluidide is reputed to have some synergistic activity with other herbicides in some plants, as treatments of mefluidide with acifluorfen and mefluidide with bentazon increased the control of common cocklebur and red rice [Oryza sativa (L.)], respectively in a crop of soybeans (Hook and Glenn, 1984; Rao and Harger, 1981).

Other physiological events can occur with application of mefluidide. It increases the amount of recoverable sugar in sugar cane [Saccharum officinarum] (Gates, 1975) and tall fescue [Festuca arundinacea Schreb.] (Glenn et al., 1980) while decreasing the yield of sugar in sugar beets (Schweizer and Eshel, 1978). Jobling (1978) indicated the use of mefluidide as a ripening agent in sugar cane. Protein content also was increased in tall fescue by mefluidide (Glenn et al., 1980). Tseng and Li (1984) indicated that mefluidide allowed cucumbers and corn to protect themselves against low temperature stresses. Glenn and Rieck (1985) found that mefluidide had auxinlike activity at low concentrations because it stimulated elongation of corn coleoptiles.

Mefluidide is absorbed mostly through the young leaves and stems and translocated via the assimilate stream to the areas of high metabolic activity, ie. movement is acropetal to the apical regions of the plant and the axillary buds (Bloomberg and Wax, 1978). Absorption and translocation differs according to species but also varies according to the environmental conditions (McWhorter and Wills, 1978). An increase in temperature from 22^{0}C to 32^{0}C and relative humidity from 40% to 100%, resulted in a 2-3 fold increase in absorption and a 4-8 fold increase in translocation. The mode of action of mefluidide is not clearly known but it is speculated that mefluidide inhibits the biosynthesis of gibberellins. Wilkinson's (1982) work on sorghum suggests this to be the case since the conversion of kaurene to kaurenol is inhibited. Both these compounds are precursors to GA_3. Truelove et al. (1977) mentions, however, that the mefluidide-induced retardation of growth cannot be solely due to the inhibition of GA_3 biosynthesis because exogenous application of GA_3 did not reverse the dwarfing affects. Truelove et al. (1977) adds that one of the earlier effects of GA_3 is on the membrane structure and permeability and mefluidide may therefore have some impact at this level. Truelove et al. (1977) also found that leucine incorporation was inhibited in cucumber [*Cucumis sativus* L. 'Ashley'] cotyledons by mefluidide suggesting that the rate of protein synthesis could be affected.

2.2 SUGAR CONTENT IN POTATOES

The sugar content of potatoes is a major concern to the potatoes industry. A high reducing sugar content can seriously affect the processing quality because of an interaction with amino acids to form a browning reaction when they are fried (Mazza et al., 1983). While sucrose is not directly involved in this process it is a substrate for reducing sugars and the quantity of reducing sugars is often sucrose related (Sowokinos, 1978). The storage capability of potatoes is another factor that can be determined by sugar content. Sowokinos (1978) found that sucrose ratings of 2.8 mg sucrose/g tuber or lower were essential for long term storage of good quality processing potatoes.

2.2.1 Sugar Content Prior to Storage

The sucrose and reducing sugar content of potatoes is normally high before harvest but this is reduced to a minimum at maturity (Mazza et al., 1983). During the maturation process the sugars are converted to starch and the enzyme ADPglucose pyrophosphorylase is the main regulatory enzyme involved in synthesis of starch (van Es and Hartmans, 1981b).

2.2.2 Sugar Content During Storage

During long term storage the sugar content in potato tubers will gradually increase but there are at least two different reasons for this sweetening taking place, one is low temperature sweetening and the other is senescent sweetening.

In low temperature sweetening, accumulation of sucrose and reducing sugars are stimulated by low temperatures but this process can be reversed by reconditioning the potatoes at higher temperatures (van Es and Hartmans, 1981b). Sherman and Ewing (1982) noticed that within 2 days of chilling there was an increase in hexose phosphates and after 10 days sucrose was synthesized. Burton (1969) found that in the cultivar 'Majestic' when the temperature was reduced from 10°C to 2°C the sucrose content of young tubers was increased from about 0.1% to around 1.0% of fresh weight and reducing sugars from 0.2% to about 1.7%. Burton (1969) indicated that amount of sugar accumulated in response to cold temperatures depended on the age of the tubers and on the cultivar. It was also found that the sugar accumulation was not as great when the temperature was reduced gradually (Burton, 1969).

There are a number of theories that try to explain this increase in sugars at low temperatures. Isherwood (1976) postulates that there is a steady state level of starch and sugar at a certain temperature, ie. starch is being degraded and produced continuously but this is shifted one way or another depending on the temperature. This response occurs because there is a balance between electron transport activated influx of metabolites into the amyloplasts where starch is formed, and a passive efflux of intermediates (Isherwood, 1976). The intermediate that accumulates in the cytoplasm is sucrose. A decrease in the temperature would, according to this hypothesis, affect the electron transport-activated influx, and therefore increase the amount of sucrose. Dixon and Rees (1980) concluded that phosphofructokinase and pyruvate kinase are cold labile causing glycolysis to be blocked which in turn diverts the hexose phosphates into sucrose production. Pollock and ap Rees (1975) indicated that accumulation of sugars at low temperatures was due to an activation of certain enzymes, namely sucrose phosphate synthase. Invertase, the enzyme that converts sucrose to reducing sugars also is reported to be stimulated at low temperatures (Pressey, 1969).

Activation of cyanide resistant respiration (CRR), as mentioned later, may also be responsible for the increase in the sugar content of potatoes at low temperatures (Sherman and Ewing, 1982; Solomos and Laties, 1975). While CRR is not usually known to increase ATP levels in plant tissue Solomos and Laties (1975) found the ATP levels to be increased in potatoes and suggested that sucrose synthesis functions as a sink for this excess energy that is produced. Isherwood (1976) claims HCN and other treatments that increase sugar content (anaerobiosis, ethylene chlorhydrin) have their effect on the amyloplast membranes and might even affect the electron transport properties of the membrane.

Some workers have concluded that the membranes surrounding the amyloplasts become leaky at low temperatures, thus making the starch available to the hydrolyzing enzymes that are located in the cytoplasm (Shektar et al., 1979). Other research recently, however, indicate that this leakiness is more of an indication of age or senescence than a factor of temperature (Isherwood, 1976).

Senescent sweetening, as opposed to low temperature sweetening, is not reversible (Isherwood, 1976). This type of sweetening occurs after the potatoes have been in storage for a certain length of time with various cultivars having different responses (Burton, 1978). The cause for this sweetening as mentioned above, is that the membrane around the amyloplasts become leaky or disintegrates thus allowing enzymes like starch phosphorylase to break down its contents (Isherwood,1976). Lower temperatures of 2^0-4^0C helps to prevent senescent sweetening but low temperatures increase sweetening if senescence has already been initiated (Burton, 1969). Preharvest conditions, such as water stress, also affect the storeability of potatoes and the accumulation of sugars for the same reasons mentioned before, ie. it increases the permeability of the membranes (Shektar et al., 1979).

2.3 RESPIRATION IN POTATOES

2.3.1 Respiratory Process

Respiration in potato tubers is a process by which carbohydrates are broken down or oxidized and CO_2, energy, and heat are released. The process is simplified by the following equation:

$$C_6H_{12}O_6 + 6O_2 \text{ ----> } 6CO_2 + 6H_2O + \text{energy} + \text{heat}$$

The main substrate for respiration is starch which is converted to hexose units, namely glucose, by the enzyme phosphorylase (Shektar and Iritani, 1978), or if the carbohydrate is in the sucrose form then invertase is active in producing the reducing sugars (Pressey, 1969). From here the reaction progresses through the glycolytic pathway to pyruvate and then through the tricarboxylic acid (TCA) cycle or it will enter the pentose phosphate pathway (PPP) (Sherman and Ewing, 1983).

This process of respiration is an important physiological activity in the potato, even in storage, since it provides the energy needed to maintain metabolic activity and life processes in the tuber (Rastovski, 1981). Energy from these cycles is stored in the form of ATP, NADH + H^+, or $FADH_2$ (Salisbury and Ross, 1978). The electrons from NADH + H^+ and $FADH_2$ are transported through the electron transport system which is coupled with oxidative phosphorylation to produce more ATP. This stored energy contributes to the synthesis of DNA, RNA, protein, and enzymes, and other substances that maintain the integrity of the organism (Wills et al., 1981). Senescence occurs when the integrity and the metabolism of the organism deteriorates or declines (Nooden, 1980). Another aspect of glycolysis and the TCA cycle is that certain intermediates are used as a source of carbon skeletons for many synthetic reactions in the cell such as the production of fats and proteins (Wills et al., 1981).

While respiratory activity is important for maintainance of the potato tubers in storage, it is still deemed important to control this process. First of all it is important to control respiration because it accounts for part of the weight loss in the tuber. Under normal circumstances weight loss due to respiration is responsible for about 10% of total weight loss during storage (Burton, 1978; Schippers, 1977c). The balance of the losses are due to the loss of water. Secondly, the levels of CO_2 in storage facilities should not be too high otherwise detrimental physiological consequences could be induced such as loss of resistance to diseases such as Fusarium and the occurrence of black heart (Workman and Twomey, 1970), or elevated sugar levels (Shamaila, 1985; Workman and Twomey, 1970). Finally, in elevated CO_2 storage conditions the respiratory activities can be altered but so far the studies regarding the effect of CO_2 have not been very conclusive. Perez-Trejo et al. (1981) showed that the respiration rate increased in these conditions whereas Schippers (1977b) found high CO_2 concentrations inhibited respiration.

2.3.2 Effect of Maturity on Respiration

The physiological maturity and the duration of storage influence the respiration rate of the potato tuber. Peterson et al. (1981), working with recently harvested potatoes, determined that immature Russet Burbank tubers respired at about 3 times the rate of mature tubers, ie. approximately 6-8 and 2.5-1.5 mg CO_2*kg $tuber^{-1}$*hr^{-1} for immature and mature tubers, respectively. Burton (1964) found a similar trend in that immature tubers respired at a rate of about 30 mg CO_2*kg tuber^{-1}*hr^{-1} while at field maturity the respiratory rates were reduced to approximately 10 mg CO_2*kg tuber^{-1}*hr^{-1}. Immaturity of the potato tuber is a relative term indicating that the tuber has potential to increase its size and that physiological characteristics such as the starch content are relatively low at this stage (Cutter, 1978). After 6-8 weeks in storage the respiration rate of potatoes are further reduced to a plateau ranging from 3-8 mg CO_2*kg tuber^{-1}*hr^{-1} (Burton, 1978) and Schippers (1977b) found the respiration rate to be reduced to 1-3 mg CO_2*kg tuber^{-1}*hr^{-1}. The reason for higher rates of respiration for immature tubers than tubers that have been in long term storage is that as tubers mature the metabolic rate decreases since they are no longer actively growing (Burton, 1982). Towards the end of the storage period, which is often 6-8 months long, the respiration rate usually increases slightly. This is usually considered to be in response to sprouting (Dewelle and Stallknecht, 1978; Isherwood and Burton, 1975; Schippers, 1977c).

The relatively high respiration at harvest compared to the rate later in storage is not only due to maturity but also has to do with bruising and other damage to the tuber occuring during harvest. Pisarczyk (1982) determined that mechanical harvesting bruised tubers to a greater extent than hand harvesting and subsequently doubled the rate of respiration for the first 1-2 weeks in storage.

2.3.3 Respiration and the Effect of Temperature

Temperature has a direct influence on the respiration rate of potatoes. According to van Es and Hartmans (1981c) temperatures of 5-10^{0}C will result in a minimal respiration rate. At 5^{0}C respiration is about 4.5 mg CO_2*kg tuber^{-1}*hr^{-1} but it climbs to 9.5 mg CO_2*kg tuber^{-1}*hr^{-1} at 0^{0}C. Schippers (1977b) claims that between 5-10^{0}C the rate of respiration does not vary very much but if the temperature is reduced to 2.5^{0}C the rate increases 30%. In a general review of the work on respiration of potatoes Schippers (1977a,b) found that 7.5^{0}C results in the lowest rate of respiration. At temperatures above 10^{0}C, especially above 20^{0}C and beyond, respiration increased dramatically (Schippers, 1977b). In a slightly different finding Paez and Hultin (1970) noted that at 1^{0}C and 4^{0}C there was a similarly low rate of respiration and at 12^{0}C and 21^{0}C the rates began to increase.

Respiration is also influenced by temperature changes. Temperature reduction of 10^{0}C to 2^{0}C initially decreased respiration but was followed a few days later by a respiratory burst (Isherwood, 1973). Amur et al. (1977) noticed this burst in respiration only in fresh tubers and not in tubers that were aged for 3 months in storage. This respiratory burst was sustained for 20-23 days before it was reduced to a level slightly higher than it was initially at 10^{0}C. Isherwood (1973) found that the reverse was also true, that when the storage temperature was increased from 2^{0}C to 10^{0}C respiration increased to a maximum after about 10 days and then decreased close to the original level after this.

The reasons for increased respiratory activity at extreme temperatures or with drastic temperature changes are not exactly clear. Some indicate that increased production of sucrose and reducing sugars triggered by low or changing temperature are responsible for the higher respiration rate (Sparks, 1965; Isherwood, 1976). But others indicate that these storage temperatures are one of many environmental stresses that increases both respiration and sugar accumulation but that these two variables are independent of each other (Amur et al., 1977; Paez and Hultin, 1970). Cynanide resistant respiration is also given as a reason for increased respiratory activity at low temperatures.

2.3.4 Inhibitors of Respiration and Cyanide Resistant Respiration

Normal respiration of most organisms is very sensitive to compounds such as cyanide (HCN), and carbon monoxide, which bind with the iron in cytochrome oxidase thus inhibiting electron transport and respiration itself (Bendall and Bonner, 1971; Salisbury and Ross, 1978). However, this poisoning of the electron transport system only has a minor effect on respiration in some plants, in fact respiration may be stimulated. This form of respiration, ie. insensitive to HCN, is referred to as cyanide resistant respiration (CRR) and is an alternative to the regular electron transport chain pathway. Sherman and Ewing (1982) and Solomos and Laties (1975) found that respiration and sugar accumulation increased in potatoes treated with HCN, and suggested that CRR may be related to activities that are normally associated with low temperature stimulation of respiration. ATP levels also increased in response to HCN treatments (Solomos and Laties, 1975).

2.3.5 Effect of Sugars on Respiration

Some early workers, as mentioned earlier, suggested that sugar content directly affected the rate of respiration, ie. the higher the sucrose content the higher the respiration rate (Isherwood, 1976; Sparks, 1965). This is compatible with increased respiration and sucrose content at low temperatures. Other workers, however, found that addition of sucrose as a substrate under favorable conditions did not have a positive response in increasing respiration (Craft, 1967). It was also found that respiration increases at low temperatures preceded sucrose accumulation (Workman et al., 1979). The overall results from these and other studies suggests that increases in sugar content are not correlated with respiration and are therefore independent of each other (Amur et al., 1977; Paez and Hultin, 1970; Workman et al., 1979).

2.4 WEIGHT LOSS

Weight loss is of economical concern to the potato producers. Burton (1973) indicates the weight loss, in terms of money, to be second only to that of diseases. Under optimal conditions in storage the loss in weight can be from 3.4-3.8% of original weight while losses up to 17% have been reported (Burton, 1978). A number of physiological events affect weight loss, including the skin or periderm formation and the respiratory activity. Of this loss in storage, 90% is assumed to be water loss and 10% respiratory loss (Rastovski, 1981). The potato periderm normally is the barrier to water loss while the magnitude of the metabolic activity reflects the potential loss of weight due to respiration.

2.4.1 Periderm Formation and Evaporative Weight Loss

The periderm is a tissue of secondary origin that functions as a protective barrier between the tuber and the outside environment (Esau, 1977). Butchbaker et al., (1973) claims that evaporative weight loss depends on the permeability of the periderm. The periderm formation also includes suberization since it is the suberization that is considered critical in preventing water loss and the resistance to water loss is proportional to the amount of suberin deposition (Kolattukudy and Dean, 1974). Water evaporation from a cut, unsuberized surface is about 300 times the loss from potatoes that have a mature surface (Burton, 1982). A mature surface on a potato or a good skin set is defined as a periderm that adheres firmly to the tuber (Yamaguchi et al., 1966). Water loss from immature potatoes is 15-100 times that of mature potatoes (Burton, 1978). The periderm is initiated in the field and factors that influence periderm formation in the field include soil type, moisture, and the general health of the plant foliage. Usually sandy soils and well aerated soils (Nielson, 1968), and low soil moisture or stressed plant conditions (Braue et al., 1983) enhance periderm formation. Death of the foliage generally hastens skin maturity (Wilcockson et al., 1980) and to this end mechanical and chemical desiccants have often been used (Murphy, 1968; Struckmeyer and Binning, 1983).

The maturation of the potato periderm in the field is usually limited, depending on the environmental conditions during the growing season. Mechanical damage during harvesting will often severely skin and bruise the potatoes. The first period of storage, referred to as the curing period, is a critical period in storage because the conditions there can help to establish a permanent periderm. The main conditions during curing, which normally lasts 10-14 days, are temperatures of 15-20°C (Artchwager, 1924) and relative humidities (R.H.) of 70-98% (Wigginton, 1974). Other factors are an adequate or normal supply of O_2 (Lipton, 1967) and low levels of CO_2 in the storage atmosphere (Wigginton, 1974).

In regular long term storage the temperature is reduced to 5-10°C while maintaining a high R.H. The weight loss in storage due to evaporation is dependent on the vapor pressure difference (VPD) between the potato and the air. The VPD is the driving force for water loss, the greater the VPD the greater the water loss (Schippers, 1971; Rastovski, 1981). The VPD is influenced by the temperature of the potato, the difference in temperature between the potato and the air, and the R.H. of the air. Temperature is the most critical variable when considering water loss in storage because of a big increase in VPD when there is a moderate increase in temperature (Butchbaker et al., 1973). It is therefore important in long term storage to be aware of the temperature and R.H. if water losses are to be subdued. The weight loss in storage also varies according to cultivar and environmental conditions during the growing season (Braue et al., 1983). Butchbaker et al. (1973) mentioned that potatoes stored in normal bulk storage lose less weight than potatoes stored in experimental conditions because there is usually a smaller surface area of the potato exposed to air flow.

2.4.2 Respiratory Weight Loss

Respiration results directly in the loss of dry matter, namely carbohydrates, and accounts for losses of no more than 0.5 to 0.6% of the fresh weight of potatoes (Rastovski, 1981). It is mentioned that respiration also is indirectly responsible for weight loss in another way. Heat is a product of respiration and if the potatoes are to be kept cool this heat must be removed. As potatoes are cooled, water evaporates thus resulting in water loss. There has been some attempt to correlate respiration to overall weight loss in potatoes but the results have not always been consistent or reliable (Schippers, 1977c).

Chapter III

MATERIAL AND METHODS

3.1 FIELD TRIALS 1983

Plots of two potato cultivars, Norchip and Russet Burbank, were planted on May 26 and 27, respectively, at the University of Manitoba Plant Science Department, Portage la Prairie Research Station in a clay loam soil. Certified seed was used and seed pieces were planted 42 or 33 cm apart for Russet Burbank and Norchip, respectively, in rows 1 m apart. Cultural conditions included: preplant incorporation of EPTC (4 L/ha) and metribuzin (0.8 L/ha) for weed control, approximately 300 kg/ha of 20-20-20 fertilizer banded during planting, periodic application of deltamethrin (300 ml/ha) to control the Colorado potato beetle and mancozeb (2.2 kg/ha) for early blight control. The potatoes were cultivated and hilled as needed.

Russet Burbank was planted in a split block design with four replications, five main plot treatments that were 18 m long, and two subplots that were each 9 m long. Guard rows were located between the treatment plots. The main plots consisted of a control and four levels of foliar-applied mefluidide, 0.25, 0.50, 1.00,and 2.00 kg ai/ha Mefluidide was applied with a CO_2 backpack sprayer with a flat fan nozzle which had an output of 106 L/ha. The subplots were the different dates mefluidide was applied to the potatoes. These dates were August 10 and 24 and this will be referred to as early and late application, respectively, later in this thesis. Plots were harvested September 28.

Norchip was planted in a randomized complete block design with four replications and five treatments that were identical to the Russet Burbank main plot treatments. Plots were 18 m long but 9 m were used for pre-harvest sucrose analysis and the rest was harvested for yield data and storage tests. Mefluidide was foliar applied August 15 and the potatoes were harvested September 23.

After harvest with a single row potato digger, both Norchip and Russet Burbank potatoes were brought into storage and graded for yield data and were retained for storage and processing analysis. In storage the temperature was initially 18°C and 70% relative humidity. On October 4 the temperature was gradually reduced to 10°C and after November 22 the temperature was lowered to 5°C.

3.2 FIELD TRIAL 1984

Norchip and Russet Burbank potatoes were planted May 17 and 18 at Carman, Manitoba in a sandy-loam soil. Cultural conditions included an application of metribuzin (1.1 L/ha) as an early postemergent herbicide on June 6 with a broadcast application of 60 kg/ha of 34-0-0 and subsequent cultivation on June 14. Mancozeb (2.2 kg/ha) and carbaryl (1.25 L/ha) were applied periodically for early blight and Colorado potato beetle control, respectively. The potatoes were cultivated and hilled as needed.

Russet Burbank was planted in a split plot design with the same main plot and subplot treatments as in 1983. The main plot treatments were 24 m long and subplot treatments 12 m long. The dates of foliar application of mefluidide were August 1 and 15 for early and late application, respectively. One subplot treatment at 1.00 kg ai/ha was accidently sprayed at both the early and late application and therefore was not used in the storage tests.

Norchip followed the same design and treatments as in 1983. The plots were 24 m long and 9 m were used for pre-harvest sucrose analysis while 15 m were harvested.

Both Russet Burbank and Norchip were harvested on September 19. Once again the potatoes were graded for yield and retained for storage and processing analysis. The storage conditions were the same as in 1983 except the temperature was reduced to 10°C beginning October 3 and to 5°C November 20.

3.3 YIELD

Within ten days of harvesting, Russet Burbank and Norchip were graded according to tuber diameter: less than 5 cm, 5 to 8.75 cm, and over 8.75 cm, which correspond to undersized, marketable size, and oversized tubers, respectively. Russet Burbank potatoes that were of marketable size but had deformities such as knobbiness were not graded as marketable but were classified separately as deformed potatoes.

3.4 SPECIFIC GRAVITY

About three weeks after harvest, ten tubers from each plot were removed for specific gravity analysis. The potatoes were weighed in air then weighed in water that was at room temperature. The formula used to calculate specific gravity (SG) was the following:

SG = [weight(g) in air]/[weight(g) in air - weight(g) in water]

3.5 CHIP COLOR

Five tubers selected from the marketable grade of Norchip were removed from each plot approximately three weeks after harvesting for chip color analysis. Potatoes were washed and peeled, and ten slices about 1.5 mm thick were cut from the center of each potato on a rotary slicer. The slices were rinsed in water to remove excess starch, padded dry with towels, and then fried in canola oil, supplied by CSP Foods, Altona, at 190°C till the bubbling from the slices ceased (approximately 2 minutes). The chips were placed into plastic bags after they were cooled and the bags were sealed until color rating determination. A Hunterlab spectrometer Model D25 was used for color determination by reading the L-value of the chips. The L-values were then converted to agtrons by the following formula:

Agtron = [L-value X 1.24427] - 17.3943

The agtron values are the common measurement for chip color and the value ranges from 1-100. A minimum agtron value of approximately 40 is considered acceptable for good chip color.

3.5.1 Sampling Selection for Sucrose Analysis

3.5.1.1 Pre-harvest Sampling

Eight average sized tubers were selected from five plants in each plot in the Norchip trials the day of mefluidide application and every week thereafter up to harvest for a total of five sampling dates. In 1983 the sampling included all treatments but in 1984 only the control, 0.50, and 1.00 kg ai/ha mefluidide treatments were sampled.

3.5.1.2 Storage Sampling

Five average-sized tubers were selected from each plot of Norchip and Russet Burbank. Sampling began immediately after harvest and then once every month for a total of seven sampling dates for Norchip. For Russet Burbank sampling took place at harvest and then every other month for a total of four sampling dates.

3.5.2 Sucrose Extraction

The potatoes that were selected for sucrose analysis were prepared according to the method described by Sowokinos (1978) for sucrose extraction. The tubers were washed, peeled, and pieces cut from the central portion of the tuber to total approximately 200 g and then juice was extracted from them in a Braun vegetable juicerator. Ninety ml of cold water was poured into the juicer three times 1.5 min apart to remove as much sucrose from the pulp as possible. The total volume of the extract was noted and it was allowed to settle for 1 hr in an ice bath before 10 ml of the extract was placed into sealed vials and stored in a freezer till sucrose determinations could be made.

3.5.3 Sucrose Determinations

The frozen tuber extract was allowed to thaw at room temperature. One ml of extract was diluted to 5 ml with water then 0.1 ml of diluted extract was placed in a test tube. Each sample was run in triplicate. Blanks (0.1 ml water) and a sucrose standard (0.1 ml = 0.1 mg) were run with each group of determinations. To each test tube 0.1 ml of 30% KOH was added then the sample was heated at 100°C for 15 min to destroy reducing sugars. The samples were then cooled to room temperature and 3 ml of anthrone reagent was added. Anthrone reagent was prepared by mixing 150 mg anthrone with 106 ml diluted sulfuric acid. Sulfuric acid was diluted by adding 76 ml of concentrated solution to 30 ml water. The test tubes were incubated in a water bath at 40°C for 40 min and allowed to cool to room temperature before taking absorbance readings at 620 nm. The following formula gives the Sucrose Rating (SR = mg Sucrose/g tuber):

$$SR = [OD_{extract} \times 0.1 \text{ mg Sucrose} / OD_{std}] \times \text{Dilution factor}$$

where:

ODextract = Absorbance reading of the extract
ODstd = Absorbance reading of the standard
Dilution Factor = $\frac{\text{total extract(ml)}}{0.1\text{(ml) assay volume}} \times 5\text{(extract dilution)} / \text{g tuber}$

The dilution factor sometimes changed depending on changes in the total extract volume.

3.6 TUBER RESPIRATION

3.6.1 Rate of Respiration

The method of respiration analysis followed the format of Schippers (1977b) with a few modifications. Glass jars with a 4120 ml capacity and with rubber septums in the lids were used as containers for the respiration studies on the whole tuber. Ten average-sized Norchip or eight Russet Burbank potatoes from each plot were placed in the jars and parafilm was placed over the lip of the jar before the lid was put on to tightly seal the contents. The respiration studies were conducted in the potato storage facility therefore the conditions of the experiment were similar to the actual storage conditions. After approximately 2 h, a 30 ml plastic syringe was inserted into the jar through the septum and was pumped 12-15 times before removing about 15 ml of air. A 0.5 ml portion of this was removed by a 1 ml precision syringe and injected into a Carle Analytical Gas Chromatograph (AGC-311) which had a thermo conductivity detector with a filament sensor. The gas chromatograph operated at 70°C and had helium as the carrier gas at 276 kPa. The formula used to determine respiration rates was the following:

$$\text{Respiration Rate} = \frac{(\%CO_2)0.01(4210\text{ ml} -(\text{volume of tubers in ml}))1.85}{\text{hours X kg tuber}}$$

where:

$\%CO_2$ = $\%CO_2$ in jar - $\%CO_2$ in empty jar
4210 ml = volume of jar
1.85 = factor to convert ml CO_2 to mg CO_2

This formula gives the rate of respiration in mg CO_2 kg tuber^{-1} hour^{-1}.

Respiration was determined 7-10 days after harvest and then every month for seven months. The same potatoes were used for each respiration determination throughout the duration of storage but the potatoes were removed from the jars immediately after each determination. Only the potatoes that had received 0.00, 1.00, and 2.00 kg ai/ha mefluidide as a foliar application were used in this study.

3.6.2 Weight Loss Due to Respiration

The loss of CO_2 was determined by taking the mean respiration rate between consecutive respiration determination dates and converting it to g CO_2*kg tuber^{-1}*storage period^{-1}. From this the net carbon loss was determinded since for every CO_2 evolved O_2 is absorbed. The net loss of carbon is considered to be the respiratory loss (Burton, 1966). The mean respiratory loss for each period were totalled to give total loss due to respiration.

3.7 WEIGHT LOSS

After grading, approximately 3 kg of potatoes were removed from each plot and were placed into small perforated nylon bags. They were immediately weighed and then reweighed about every thirty days until the end of March or beginning of April. From these results percentage weight loss were calculated.

3.8 SPROUTING IN NORCHIP AND PERIDERM COLOR IN NORCHIP AND RUSSET BURBANK

Sprouting in Norchip was determined at the end of the storage period in March of 1984 and 1985. Five tubers from each plot were evaluated for the length of the sprouts. Periderm color and texture were visually evaluated during grading on a scale of 1 to 5, 1 being normal skin color and texture and 5 being dark brown and very russetted.

3.9 GROWTH ROOM STUDIES ON NORCHIP POTATOES

Two different growth room experiments were conducted on Norchip potatoes. In the first experiment young Norchip potato plants were grown in a growth cabinet with nutrient solution to study the effect of mefluidide on the growth of the plants by examining plant height, fresh weight, and dry weights of the foliage, roots, and tubers. Cuttings (4-5 nodes) were made from mother plants, then placed into a flat containing vermiculite, and finally put into a misting chamber for approximately 2 weeks or till a good root growth developed. Individual cuttings were then transplanted into 15 cm clay pots with vermiculite as the medium. Hoagland's half strength nutrient solution was given to the plants every other day. After the plants were 2 weeks old (from time of transplanting), they were treated, to wetness, with 4 levels of mefluidide (foliar-applied): 0.00, 0.05, 0.10 or 0.20 mg ai mefluidide/ml solution. Mefluidide solutions were prepared in 2% (v/v) acetone. The plants were harvested and weights taken 4 weeks after being treated. The growth cabinet studies were conducted 2 different times and the experiment was arranged as a double latin square. The results were combined for both dates. The foliage and roots were oven dried while the tubers were vacuumed dried.

The second experiment was designed to examine the effect of mefluidide on older Norchip potato plants in a growth room. The procedure was the same as above but the cuttings were placed in 24 cm clay pots. The mefluidide treatments were also the same except that spraying was delayed for 2 months after transplanting. Fresh and dry weights were taken of the foliage and fresh weights and some scanning electron microscopic work was done on the tuber periderm. This study was conducted once and analyzed as a latin square.

The potato plants were grown under conditions of 14 hours light in the growth cabinet and 16 hours in the growth room. The temperature was 20^0 and 15^0 for the light and dark periods, respectively.

3.10 STATISTICAL ANALYSIS

The data from Norchip was analyzed as a randomized complete block design while Russet Burbank was analyzed as a split block in 1983-84 and as a split plot in 1984-85. The analysis of variance or general linear model procedures were used in all cases. The late application of mefluidide on Russet Burbank was also analyzed separately as a randomized complete block design. In the thesis the main comparisons in Russet Burbank will be between treatments at the late application and also between late and early application. Least Significant Differences at the 5 percent level were used to determine the differences between treatment means for the yield, storage tests, and growth room studies.

3.10.1 Scanning Electron Microscopic Observations of Potato Periderm

Potato tubers of the cultivar Norchip that had been harvested from plants grown in the growth rooms in vermiculite medium with nutrient solution were used for scanning electron microscopic (SEM) observations. Small sections of potato were cut with a razor blade and fixed in 2% gluteraldehyde in 0.1 M phosphate buffer, pH 7.0, overnight. The sections were rinsed thoroughly in the same buffer then post fixed in 2% OsO_4 for one hour in the same buffer. Dehydration was carried out in a standard graded ethanol series. The sections went through a critical drying procedure before being coated with gold and viewed in the SEM. The procedures followed the outline by Soliday et al. (1979) and modified by Luit (1985).

Chapter IV

RESULTS AND DISCUSSION

4.1 YIELD

The data for total yield did not show any conclusive results for a mefluidide effect in either Russet Burbank (Table 1 and 2) or Norchip (Table 3 and 4) in the field studies, in fact the results are somewhat variable. The Russet Burbank total yields did not differ significantly in either 1983 or 1984 but in 1983 the 2.00 kg ai/ha did have a lower yield than the other treatments. The Norchip total yields showed no significant differences between treatments although the yields at the 0.25 kg ai/ha were amongst the highest. in both 1983 and 1984.

The marketable yield in the number of tubers and weight per plot of Russet Burbank in 1983 did show considerable differences (Table 1) with the control having about 5 times the yield at the 2.00 kg ai/ha rate. The number of deformed Russet Burbank potatoes, in the form of knobbiness, had almost an inverse relationship to marketable potatoes in that the control had fewer deformed potatoes than at the 1.00 and 2.00 kg ai/ha rates. The differences in the numbers of deformed potatoes was more evident when the percentage of deformed potatoes were calculated. The control, in 1983, had a low of approximately 38% deformities to a high of 83% at the 2.00 kg ai/ha rate. In 1984 the deformities were quite low, 1-3%, and there were no significant differences between treatments.

TABLE 1

1983 Yield data for Russet Burbank potatoes foliar-applied with mefluidide on Aug. 24 (per 9m row).

Mefluidide (kg ai/ha)	Marketable (#)	Marketable (kg)	Deformed (#)	Deformed (kg)	%Deformed Potatoes	Total Yield(kg)
0.00	34.75	5.84	21.25	3.84	38.65	16.88
0.25	24.75	4.05	22.00	3.99	46.83	17.83
0.50	14.50	2.35	27.25	5.36	68.63	15.53
1.00	12.25	1.90	30.00	5.15	72.00	17.80
2.00	6.50	1.00	30.75	4.40	82.90	14.20
LSD (0.05)	7.10	1.34	7.55	n.s.	11.18	n.s.

TABLE 2

1984 Yield data for Russet Burbank potatoes foliar-applied with mefluidide on Aug. 15 (per 9m row).

Mefluidide (kg ai/ha)	Marketable (#)	Marketable (kg)	Deformed (#)	Deformed (kg)	%Deformed Potatoes	Total Yield(kg)
0.00	87.19	17.96	2.63	0.73	3.10	24.99
0.25	86.44	13.03	0.75	0.24	0.87	23.16
0.50	75.38	14.49	1.13	0.43	1.57	23.27
1.00	87.94	17.16	1.13	0.34	1.35	24.98
2.00	81.94	15.58	0.94	0.45	1.15	24.06
LSD (0.05)	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

TABLE 3

1983 Yield data for Norchip potatoes foliar-applied with mefluidide (per 9m row).

Mefluidide (kg ai/ha)	Marketable (#)	Marketable (kg)	Deformed (#)	%Deformed Potatoes	Total Yield(kg)
0.00	118.75	17.46	6.75	5.71	22.38
0.25	126.75	18.79	6.00	4.69	23.38
0.50	120.50	18.33	5.75	4.78	23.80
1.00	119.25	18.86	5.00	4.24	22.46
2.00	120.25	17.46	7.50	6.36	22.16
LSD (0.05)	n.s.	n.s.	n.s.	n.s.	n.s.

TABLE 4

1984 Yield data for Norchip potatoes foliar-applied with mefluidide (per 9m row).

Mefluidide (kg ai/ha)	Marketable (#)	Marketable (kg)	Deformed (#)	%Deformed Potatoes	Total Yield(kg)
0.00	176.55	24.24	0.90	0.53	29.54
0.25	165.15	25.25	0.90	0.54	30.84
0.50	172.65	24.63	0.90	0.53	28.97
1.00	160.95	23.10	0.75	0.48	28.37
2.00	167.25	24.47	1.05	0.62	29.57
LSD (0.05)	n.s.	n.s.	n.s.	n.s.	n.s.

Norchip had very few deformed potatoes, in 1983 it averaged only 4-6% while in 1984 it was less than 1% (Tables 3 and 4).

The reason for the increase in the knobbiness of potatoes with mefluidide is not known but deformed growth, especially in Russet Burbank, is largely considered to be environmental. Hot and dry weather followed by moist conditions is known to stimulate growth in the apical areas of the potatoes (Kleinhopf, 1983). Holder and Carey (1984) found that knobby potatoes are often symptoms of poorly aerated soils. Growth cracks were also noted on the Russet Burbank potatoes grown in 1983 in response to mefluidide and these are often indicative of a midseason drought stress (Robins and Domingo, 1956).

The marketable yield for Norchip in 1983 and 1984 and Russet Burbank in 1984 showed no response to mefluidide. This is partially inconsistent with Zulu (1983) in which a slight reduction of marketable yield was noticed.

The yield differed between 1983 and 1984 for both Russet Burbank and Norchip with higher yields in 1984. The yield differences between years is often to do with environmental conditions such as length of growing season (Allen, 1978), available soil moisture and soil type (Miller and Martin, 1983), soil conditions (Sommerfeldt and Knutson, 1968), and temperature (Cho and Iritani, 1983; Gautney and Haynes, 1983). The lower yields in 1983 were due to a hot dry period during tuberization.

4.2 SPECIFIC GRAVITY

Specific gravity values showed certain trends in Norchip (Table 5) while in Russet Burbank (Table 6) the results were generally inconclusive. In 1983 Norchip generally increased in specific gravity to the 1.00 kg ai/ha mefluidide level and stayed virtually the same at 2.00 kg ai/ha. In 1984 specific gravity increased to the 0.50 kg ai/ha rate and then declined almost as quickly at the higher levels. There were, however, no statistical differences between any of the treatments.

The specific gravities of Russet Burbank in 1983 did not respond to mefluidide as consistantly as it did in Norchip but at the 1.00 kg ai/ha rate the highest specific gravity results were obtained (Table 6). In 1984 Russet Burbank results were more variable than in 1983 with the control treatment having the highest specific gravity.

The two years had quite different specific gravity levels for both cultivars (Tables 5 and 6). Russet Burbank varied the most with levels averaging 1.064 in 1983 and 1.095 in 1984. Norchip averaged about 1.087 in 1983 and 1.090 in 1984.

Reasons for differences in specific gravity are often due to environmental and cultural conditions. High soil temperature and low soil moisture, as experienced in 1983, tends to decrease specific gravity while at low temperatures and adequate soil moisture it will increase (Motes and Creig, 1970). High soil nitrogen (Painter and Augustin, 1976), potassium (Harrison et al., 1982), and possibly phosphorus have a tendency to decrease specific gravity.

TABLE 5

Specific gravity and chip color in Norchip potatoes as influenced by foliar application of mefluidide.

	1983		1984	
Mefluidide (kg ai/ha)	Specific Gravity	Chip Color (Agtrons)	Specific Gravity	Chip Color (Agtrons)
0.00	1.0860	52.08	1.0881	64.82
0.25	1.0865	53.24	1.0887	63.73
0.50	1.0862	53.01	1.0920	64.32
1.00	1.0880	54.80	1.0905	62.46
2.00	1.0882	54.74	1.0882	64.51
LSD (0.05)	n.s.	n.s.	n.s.	n.s.

TABLE 6

Specific gravity of Russet Burbank potatoes foliar-applied with mefluidide on Aug.23 and Aug.15 for 1983 and 1984, respectively.

	Specific Gravity	
Mefluidide (kg ai/ha)	1983	1984
0.00	1.0620	1.0962
0.25	1.0624	1.0930
0.50	1.0608	1.0944
1.00	1.0707	1.0951
2.00	1.0635	1.0946
LSD (0.05)	n.s.	n.s.

High specific gravity is beneficial for processing potatoes because it determines the weight of processed material that can be possibly obtained from the raw product such as chip yield (Hyde and Shewfelt, 1960). The specific gravity is an indication of the dry matter content in the tuber (Sayre et al., 1975). The quality of french fries and chips are considered to be better with high specific gravity because they absorb less oil (Lulai and Orr, 1979; Sayre et al., 1975), and specific gravity is often inversely related to the accumulation of reducing sugars (Iritani and Weller, 1976). Reducing sugars are a concern in processing because they are usually responsible for inferior color in french fries and chips.

4.3 CHIP COLOR

The chip color in Norchip (Table 5) in 1983 tended to improve with concentration of mefluidide. The agtron readings went from a low of about 52 in the control to almost 55 at 1.00 and 2.00 kg ai/ha. The agtron readings generally followed the same trends as specific gravities, ie. as specific gravities increased so did the agtrons. Hyde and Shewfelt (1960) found similar results in work with Norland and Russet Burbank potato cultivars. In 1984 the agtrons were variable, ranging from 62.5 at the 1.00 kg ai/ha level to almost 65 at 0.00 and 2.00 kg ai/ha, and there seems to be no relationship between chip color and specific gravity. Habid and Brown (1956) also reported that the specific gravity is not always a good index of chipping quality. The agtrons for 1984 were considerably improved over 1983, from around an average of 54 in 1983 to 64 in 1984. The quality and the color is improved as the agtrons increase and there is a preference for a lighter chip color by the processing industry.

Chip color is related to a number of physiological items which includes specific gravity and sugar levels. While specific gravity is not always the conclusive indicator of chip color, the sugar levels, or more particularly, reducing sugars, do have an impact on chip color (Habid and Brown, 1956). Reducing sugars react with amino acids to create a browning reaction during high temperature processing. While sucrose levels in the tubers do not contribute directly to chip color, sucrose is the precursor to reducing sugars mediated by the enzyme invertase (Sowokinos, 1978).

4.4 SUCROSE RATING

In Norchip the trend of the sucrose ratings was to decline from the time of mefluidide application for 2-3 weeks and then to increase slightly before harvest (Figures 1 and 2). In 1983 the sucrose rating (SR) started at 2.1 at the time of mefluidide application then declined to a mean value of 1.2 in 3 weeks while in 1984 it went from 1.10 to 0.30 in 2 weeks. The SR then increased to 1.4 in 1983 and 0.5 in 1984 at harvest. The SR levels are either reduced or maintained until November (day 60), after which the levels increase. In 1983-84 the SR decreased dramatically at the end of the storage period.

In Norchip there was little or no response to mefluidide in 1983-84 except that for the first three weeks after application of mefluidide the 0.00 and 0.25 kg ai/ha treatments had the lowest SR values. In 1984

Figure 1: Changes in the sucrose ratings (SR) in Norchip potatoes before harvest and during storage in 1983-84 as influenced by foliar-application of mefluidide

Day 0 = Sept. 23, 1983.

0.00 kg ai/ha mefluidide

0.25 " " "

0.50 " " "

1.00 " " "

2.00 " " "

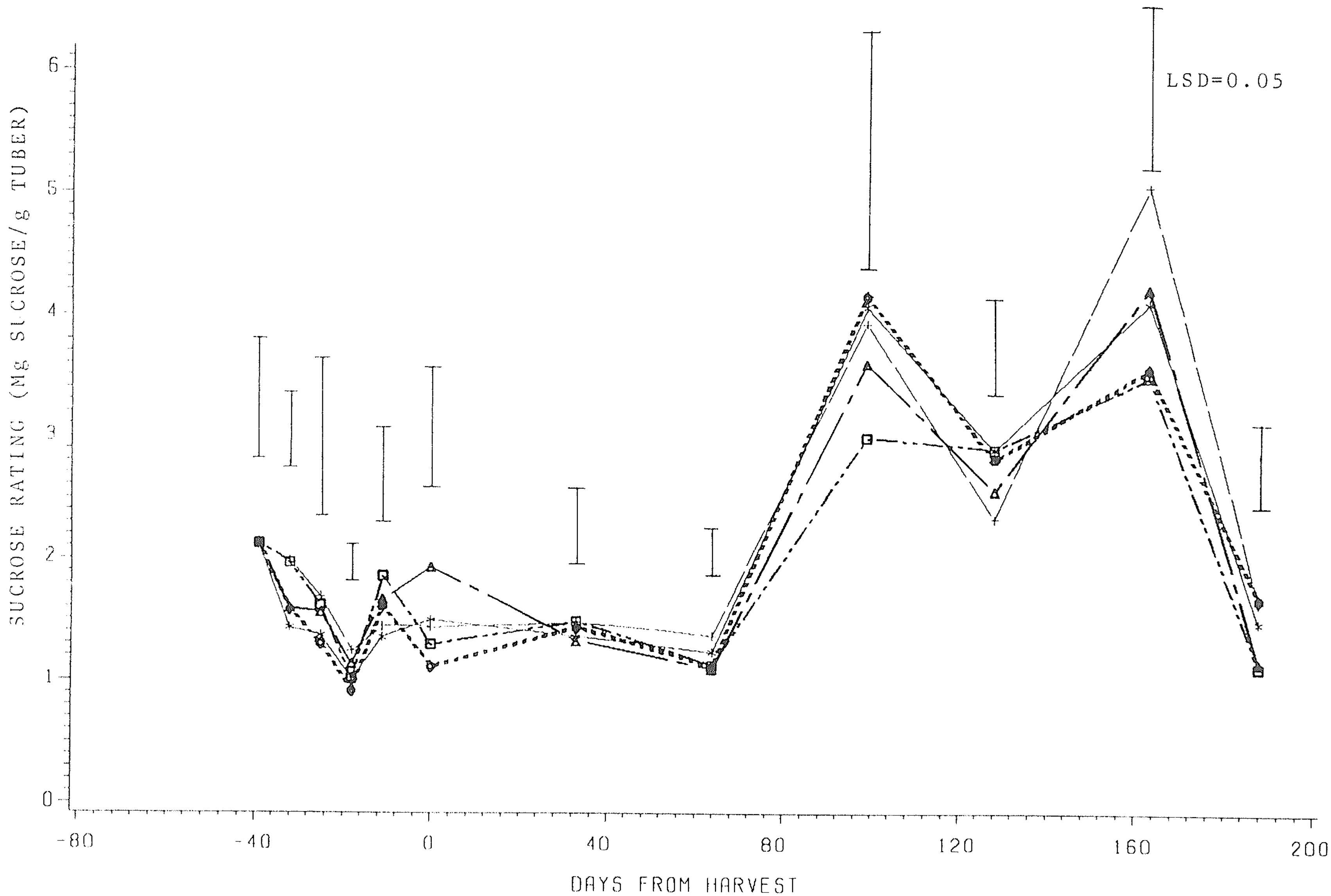

LSD=0.05
SUCROSE RATING (Mg SUCROSE/g TUBER)
0
1
2
3
4
5
6
-80
-40
0
40
80
120
160
200
DAYS FROM HARVEST

Figure 2: Changes inthe sucrose ratings (SR) in Norchip potatoes before harvest and during storage in 1984-85 as influenced by foliar-application of mefluidide

Day 0 = Sept. 19, 1984.

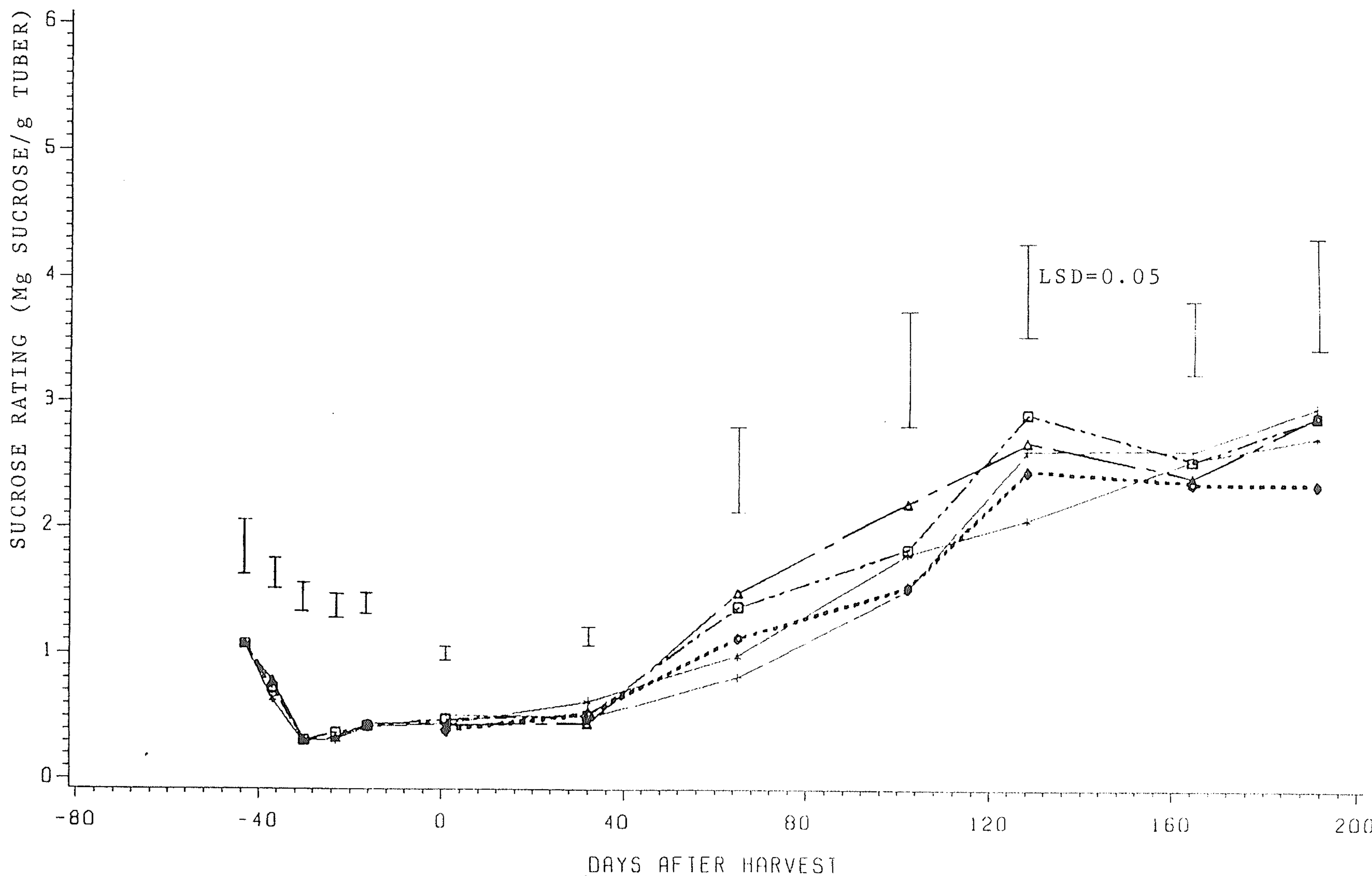
0.00 kg ai/ha mefluidide

0.25 " " "

0.50 " " "

1.00 " " "

2.00 " " "


SUCROSE RATING (Mg SUCROSE/g TUBER)
0
1
2
3
4
5
6
LSD=0.05
-80
-40
0
40
80
120
160
200
DAYS AFTER HARVEST

the control the SR was slightly lower than the 0.50 and 1.00 kg ai/ha levels during the preharvest sampling. During storage the results are again very variable and it is difficult to see any definite trends due to mefluidide treatments. The only possible trend in 1984-85 could be that the 0.00 and 0.25 kg ai/ha levels generally had a slightly lower SR values than the 0.50 and 1.00 kg ai/ha treatments. In 1983-84 the SR values reached a peak of about 5 while in 1984-85 the maximum was 3. Both of these maximum values were at the 2.00 kg ai/ha rate. The SR were generally lower in 1984-85 than in 1983-84. The increase in the sucrose content during storage runs contrary to other workers results such as Mazza et al. (1983) which showed a maintainance of a low level of sucrose during storage for both Norchip and Russet Burbank cultivars.

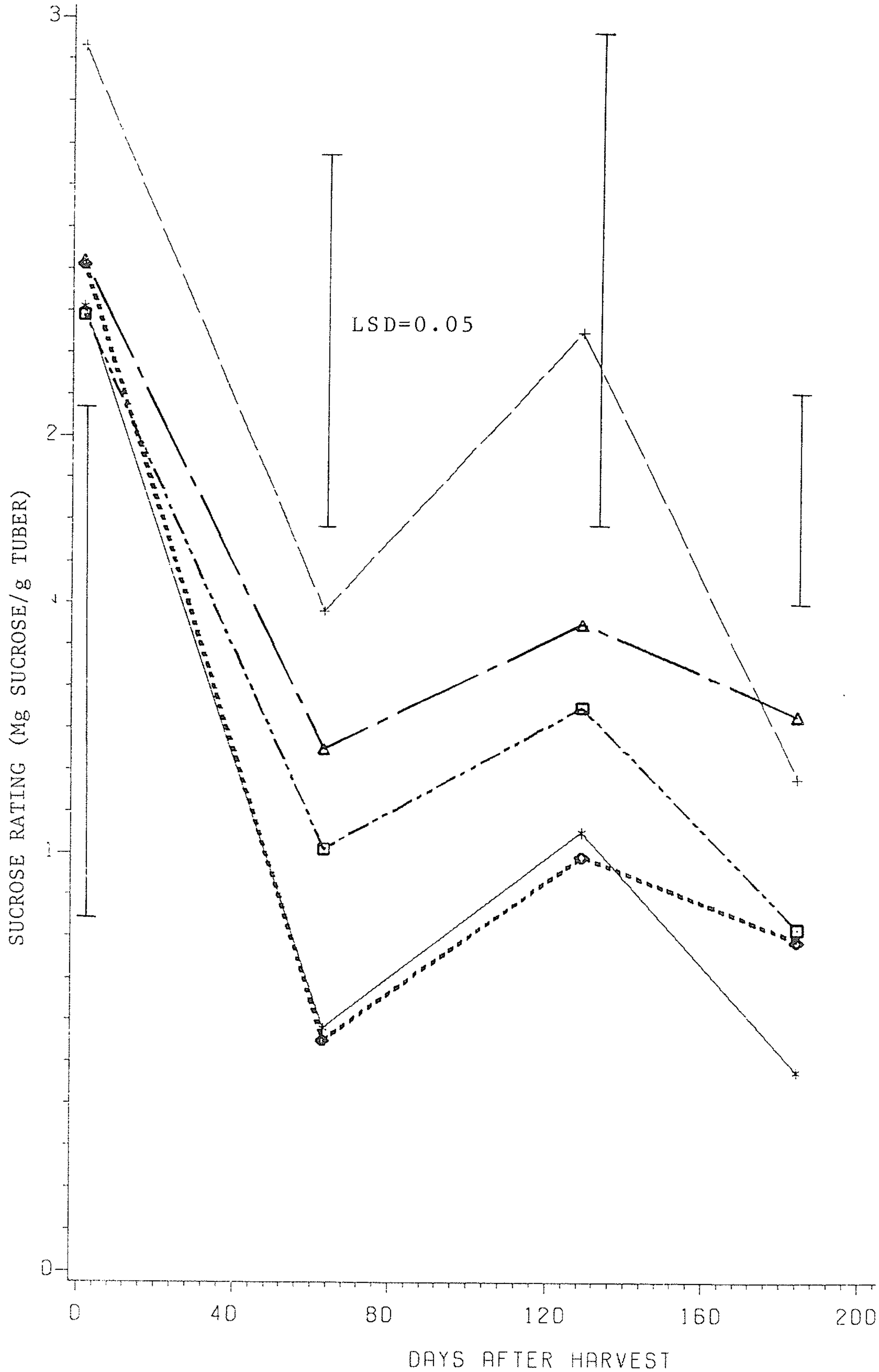
The increase in SR after November (after day 60) is possibly due to the effect of chilling on the tubers since the storage temperature was reduced to $5^{0}C$. This either stimulated the starch degradative enzymes (Shektar and Iritani, 1978) or affected the membranes surrounding the starch granules (Isherwood, 1976; Ohad et al., 1971).

The SR of Russet Burbank (Figures 3 and 4) declines considerably from harvest to November, increases in January, and then either continues to increase in March as in 1984-85 or declines once again as in 1983-84. The reason for the SR increase in November is probably very similar to that in Norchip. Why the SR trend differs in 1983-84 and 1984-85 (the same applies to Norchip) is not known but according to Isherwood (1976) there are two types of increases in sugar levels in potatoes. One is a reversible increase where the sugar level increase due to stresses such as low temperatures but then will decrease under favorable conditions,

Figure 3: Changes in the sucrose ratings (SR) in Russet Burbank potatoes during storage in 1983-84 as influenced by foliar-application of mefluidide on Aug. 24, 1983

Day 0 = Sept. 28, 1983.

0.00	kg	ai/ha	mefluidide
0.25	"	"	"
0.50	"	"	"
1.00	"	"	"
2.00	"	"	"



3
2
1
0
SUCROSE RATING (Mg SUCROSE/g TUBER)
LSD=0.05
0
40
80
120
160
200
DAYS AFTER HARVEST

Figure 4: Changes in the sucrose ratings (SR) in Russet Burbank potatoes during storage in 1984-85 as influenced by foliar-application of mefluidide on Aug. 15, 1984

Day 0 = Sept. 19, 1983.

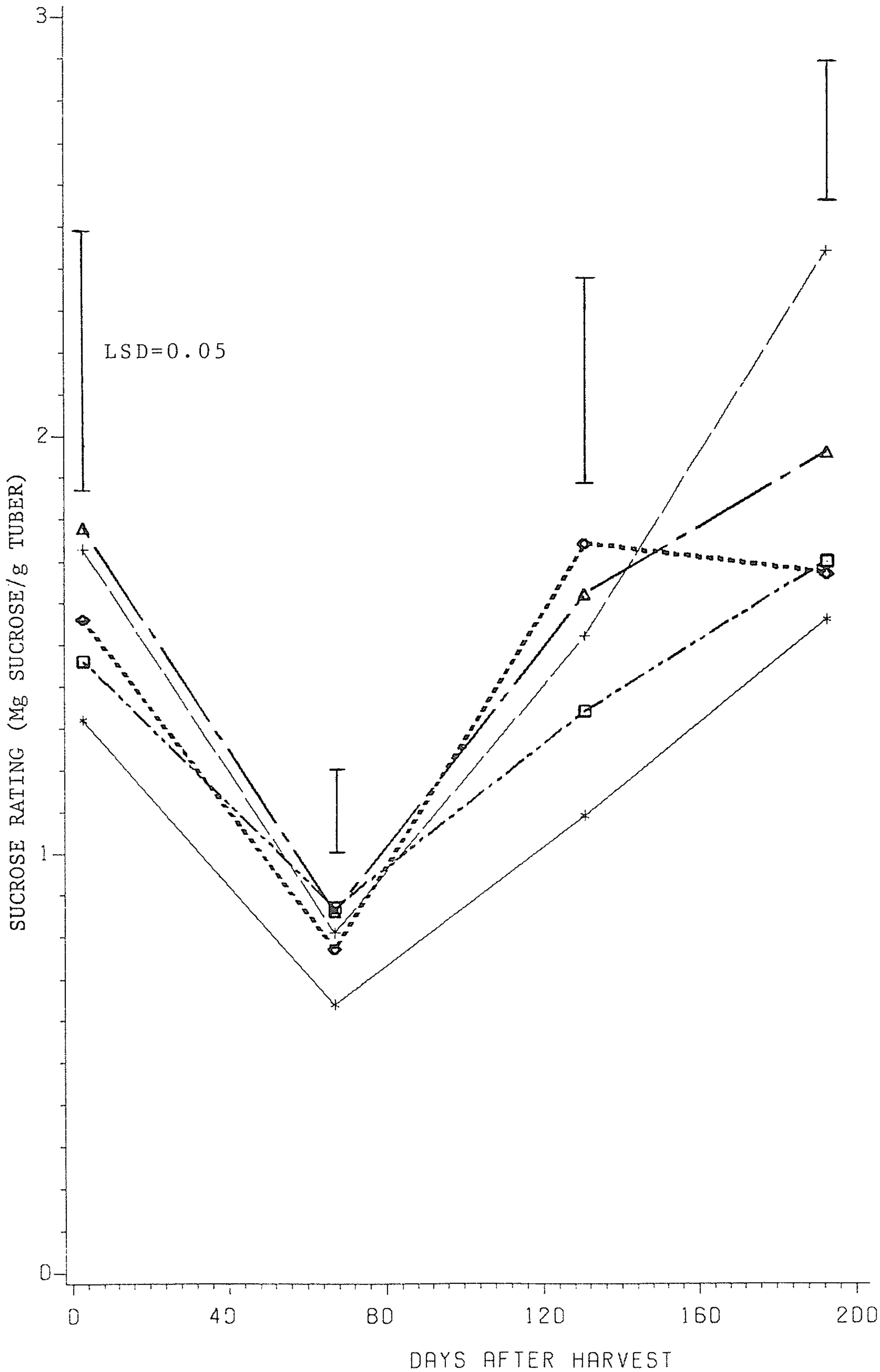
0.00 kg ai/ha mefluidide

0.25 " " "

0.50 " " "

1.00 " " "

2.00 " " "


3
2
1
0
SUCROSE RATING (Mg SUCROSE/g TUBER)
LSD=0.05
0
40
80
120
160
200
DAYS AFTER HARVEST

while the other is nonreversible due to permanent damage to the starch membranes during senescence. There is no evidence that these two physiologically different types of sugar accumulation mechanisms were in effect in the two years but it could possibly explain why the behavior was different from one year to another.

The response in Russet Burbank to mefluidide only proved to be significantly different at the end of storage for both years but the overall trend during the storage life was basically the same with the 0.00 kg ai/ha treatment having the lowest SR and 2.00 kg ai/ha with the highest throughout most of the storage period. In 1983-84 the maximum SR value for the 2.00 kg ai/ha level during storage was close to 2.2 while in 1984-85 it was 2.4.

4.5 RESPIRATION

The respiration rates in Norchip and Russet Burbank (Figures 5 to 8) started from a high rate soon after harvest to a low 2-4 months later and gradually increased thereafter. In response to mefluidide the 1.00 and 2.00 kg ai/ha treatments always had a higher rate of respiration than the 0.00 kg ai/ha except for Norchip immediately after harvest where in both both years 0.00 kg ai/ha had the highest respiration rate. Russet Burbank tended to have a greater response to mefluidide especially in 1983-84. Only on a few sampling dates, however, were the differences between the treatments significant at the 5 percent level.

Schippers (1977b) and Burton (1978) observed that at the time of harvesting respiration was high because of immaturity of the tubers. Res-

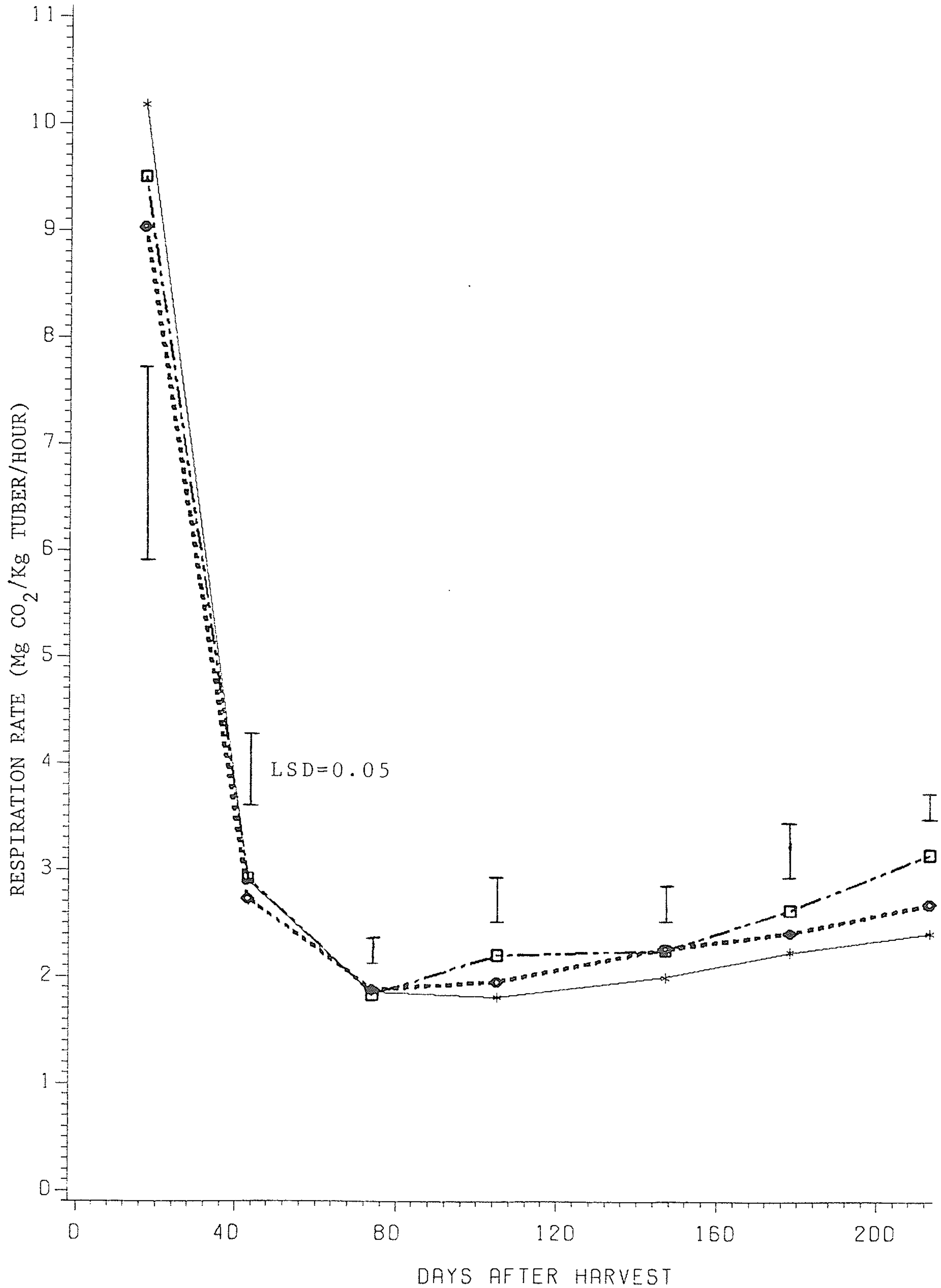
Figure 5: Effect of mefluidide on the rate of respiration of Norchip potatoes during storage in 1983-84.

Day 0 = Sept. 23, 1983.

0.00 kg ai/ha mefluidide

1.00 " " "

2.00 " " "



RESPIRATION RATE (Mg CO_2/Kg TUBER/HOUR)
LSD=0.05
DAYS AFTER HARVEST

Figure 6: Effect of mefluidide on the rate of respiration of Norchip potatoes during storage in 1984-85.

Day 0 = Sept. 19, 1984.

0.00 kg ai/ha mefluidide

1.00 " " "

2.00 " " "

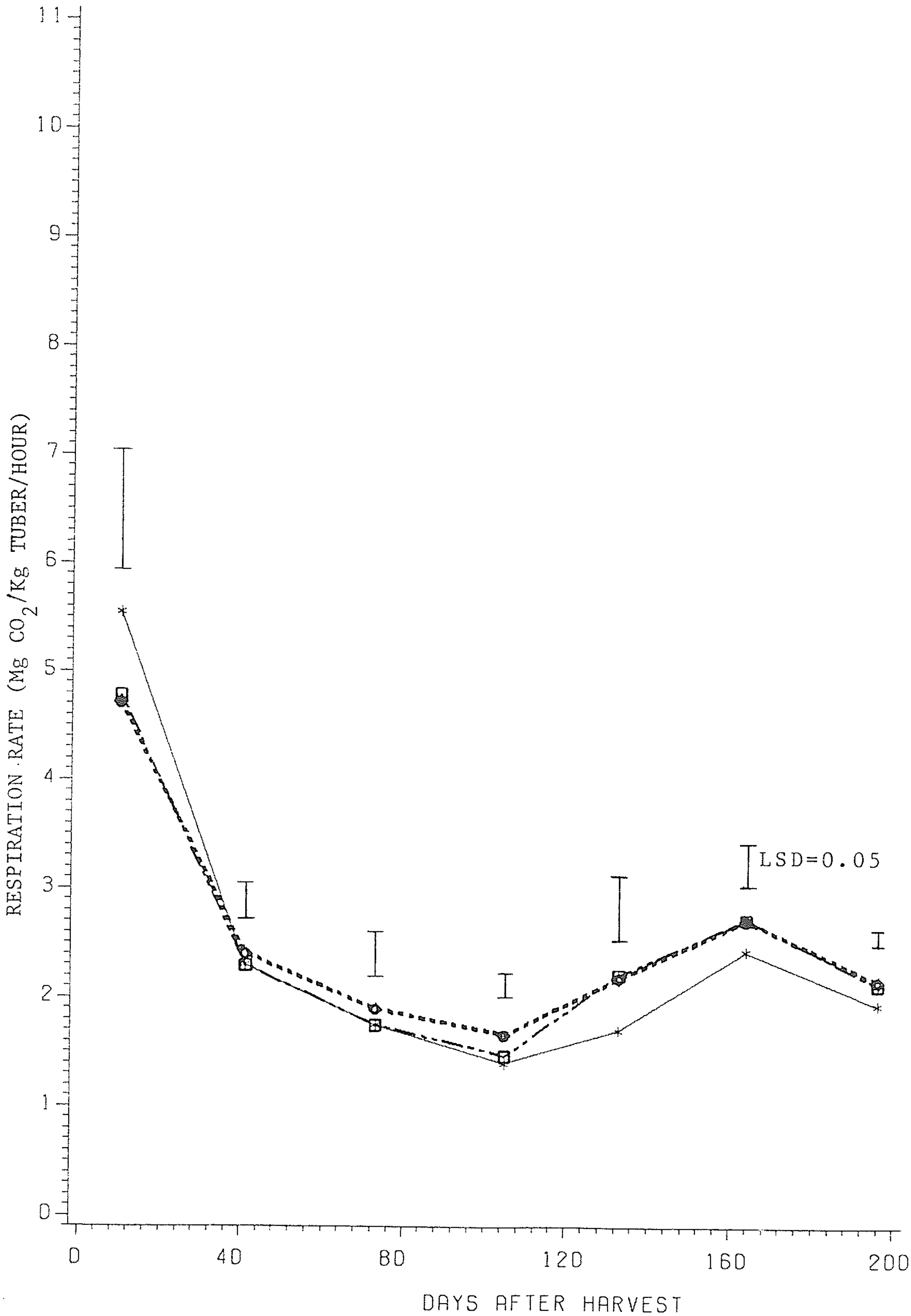

RESPIRATION RATE (Mg CO2/Kg TUBER/HOUR)
DAYS AFTER HARVEST
LSD=0.05
0
1
2
3
4
5
6
7
8
9
10
11
0
40
80
120
160
200

Figure 7: Effect of foliar application of mefluidide (Aug. 24) on the rate of respiration of Russet Burbank potatoes during storage in 1983-84

Day 0 = Sept. 28, 1983.

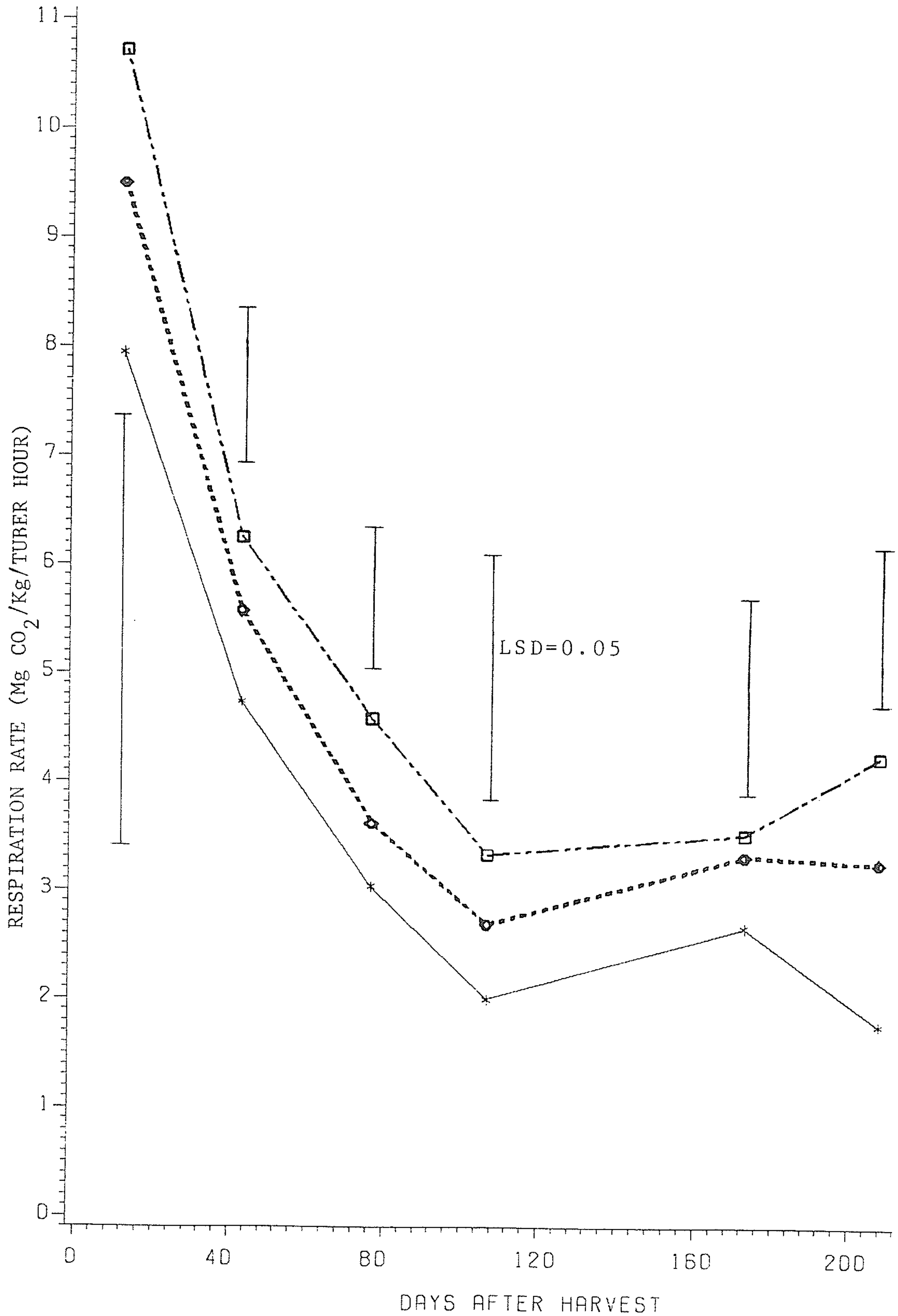
0.00 kg ai/ha mefluidide

0.25 " " "

0.50 " " "

1.00 " " "

2.00 " " "



11
10
9
8
7
6
5
4
3
2
1
0
RESPIRATION RATE (Mg CO2/Kg/TUBER HOUR)
LSD=0.05
0
40
80
120
160
200
DAYS AFTER HARVEST

Figure 8: Effect of foliar application of mefluidide (Aug. 15) on the rate of respiration of Russet Burbank potatoes during storage in 1984-85

Day 0 = Sept. 19, 1984.

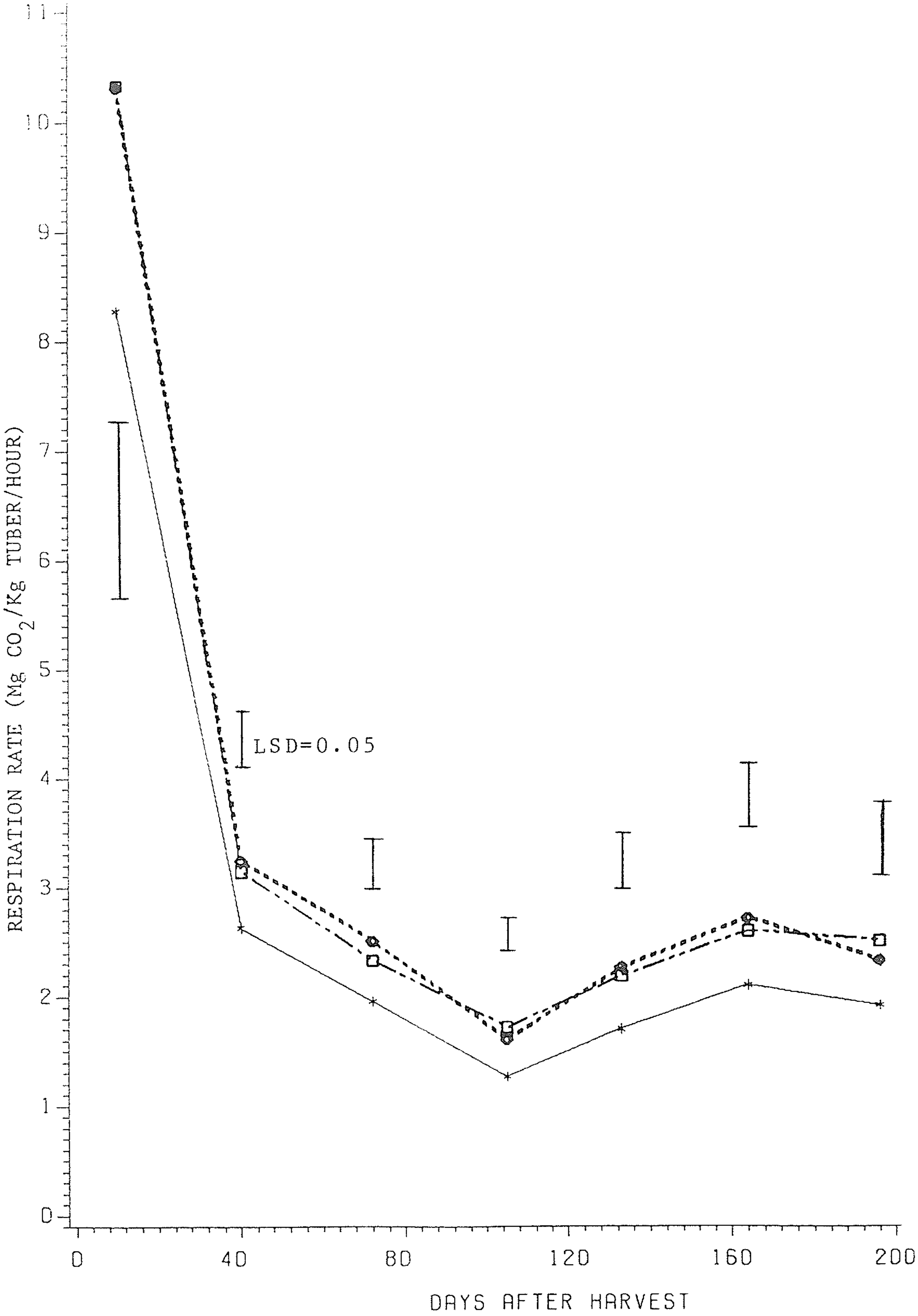
0.00 kg ai/ha mefluidide

0.25 " " "

0.50 " " "

1.00 " " "

2.00 " " "


RESPIRATION RATE (Mg CO_2/Kg TUBER/HOUR)
0
1
2
3
4
5
6
7
8
9
10
11
LSD=0.05
0
40
80
120
160
200
DAYS AFTER HARVEST

piration can also be high because of the mechanical damage incurred during harvesting and handling while grading (Pisarczyk, 1982). As the tubers mature the respiration rate decreases. If the rate of decrease in respiration and the level of respiration itself depends on the maturity of the potato it then appears in this study that Russet Burbank matures later and slower than Norchip which is generally an accepted fact. The respiration in Russet Burbank was initially higher than Norchip and also took approximately 3 months for the rate to reach its minimum value whereas with Norchip it took about 2 months. The level of maturity in the potato tubers at harvest was confirmed by visual appearances of the foliage of the plants before harvest. Russet Burbank was still fairly vigorously growing at harvest while Norchip, especially in 1984, was senescing. The respiration rate appeared to decline faster in the control than in the 1.00 or 2.00 kg ai/ha treatments Norchip, but in Russet Burbank the 1.00 and 2.00 kg ai/ha treatments decreased in respiration at the same rate as the control. While maturity may be affected by mefluidide it is not consistently obvious in the respiration results.

The respiration rate increases towards the end of the storage period starting after January (approximately 80-105 days after harvest). There are several possible reasons for this, one being that sprouting increases respiration (Dewelle and Stallknecht, 1978) and the other being the breakdown of the membrane around the starch granules thus making the starch readily available to the starch degradation enzymes (Isherwood, 1976; Ohad et al., 1971). Norchip potatoes began sprouting at the end of December and begining of January. In 1984-85, in both Norchip and Russet Burbank potatoes, the respiration rate dropped slightly for the last sampling date after it had been slowly rising since January. This may be an indication of a true reduction in respiration or it could be a change in sensitivity of the gas chromatograph.

The respiration rate appears to be independent of the the sucrose content of the tubers. While sucrose is a possible substrate for the respiratory process the respiration rate and the sucrose ratings (Figures 1 to 4) did not follow a similar pattern and therefore the respiration rate does not appear to increase in response to an increase in the sucrose rating.

4.6 WEIGHT LOSS

Weight loss from the tubers during storage is considered to be the second greatest economic loss to the potato producer (Burton, 1973). During the 1983-84 and 1984-85 storage periods for Norchip, the weight that was lost was affected by mefluidide (Figures 9 and 10). In 1983-84 the 2.00 kg ai/ha treatment lost about 20% more weight than at 0.00 kg ai/ha while in 1984-85 it was almost double. The 0.25, 0.50, and the 1.00 kg ai/ha treatments usually fell in between except in 1983-84 when the 0.25 kg ai/ha was slightly below the weight loss in the control.

Russet Burbank followed the general trend of Norchip in that mefluidide had a negative effect on weight loss (Figure 11 and 12). The 2.00 kg ai/ha rate in 1983-84 lost approximately twice the weight of the control and about 50% more than the control in 1984-85. It appears then that as far as weight loss is concerned mefluidide had a greater response in 1983-84 than 1984-85 in Russet Burbank whereas the reverse

Figure 9: Weight lost in Norchip potatoes during storage in 1983-84 as affected by foliar-applied mefluidide

Day 0 = October 1, 1983 (Date of initial weight determination)

0.00 kg ai/ha mefluidide

0.25 " " "

0.50 " " "

1.00 " " "

2.00 " " "

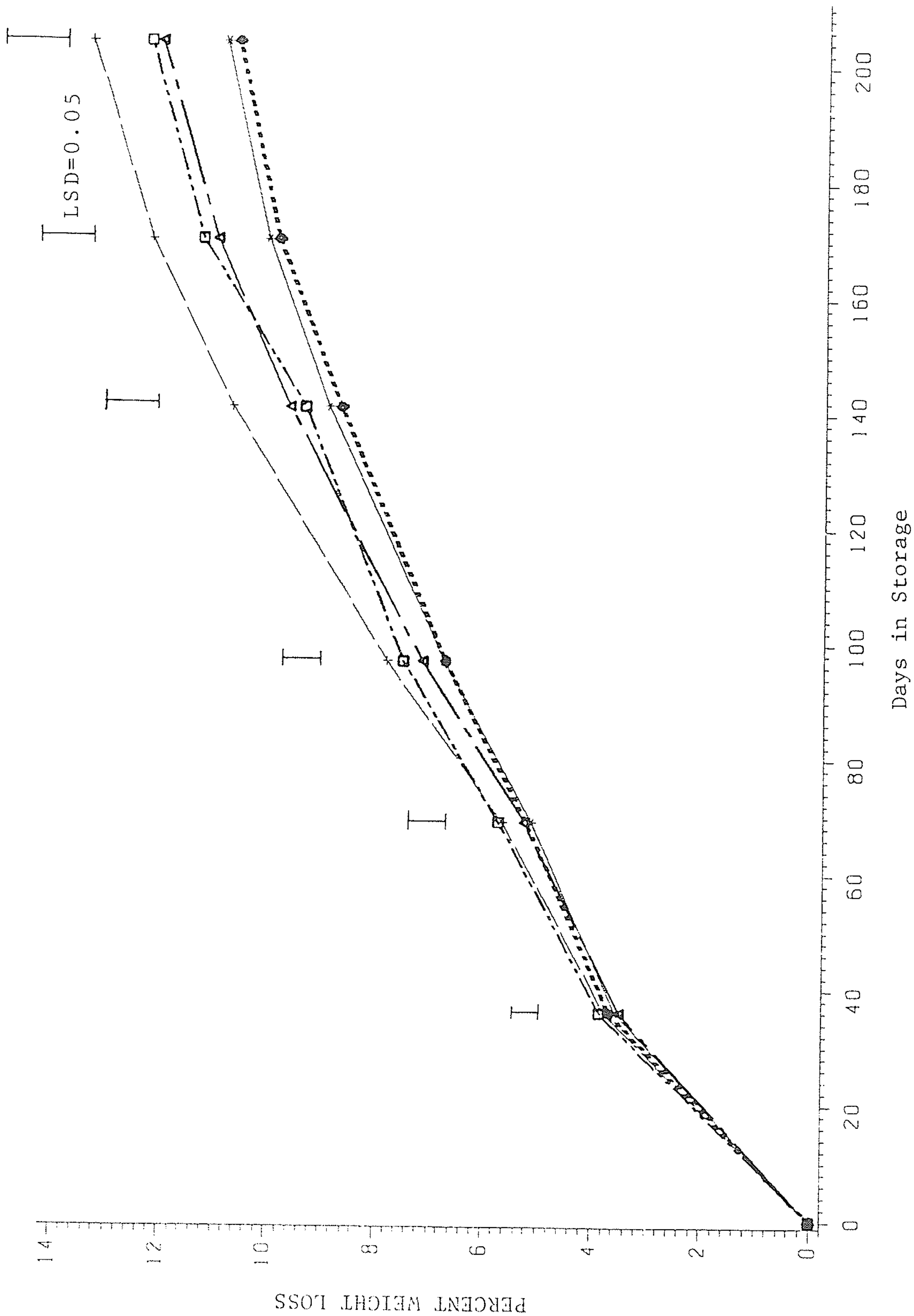

LSD=0.05
Days in Storage
PERCENT WEIGHT LOSS
0
2
4
6
8
10
12
14
0
20
40
60
80
100
120
140
160
180
200

Figure 10: Weight lost in Norchip potatoes during storage in 1984-85 as affected by foliar-applied mefluidide

Day 0 = Sept. 27, 1984 (Date of initial weight determination)

0.00 kg ai/ha mefluidide

0.25 " " "

0.50 " " "

1.00 " " "

2.00 " " "

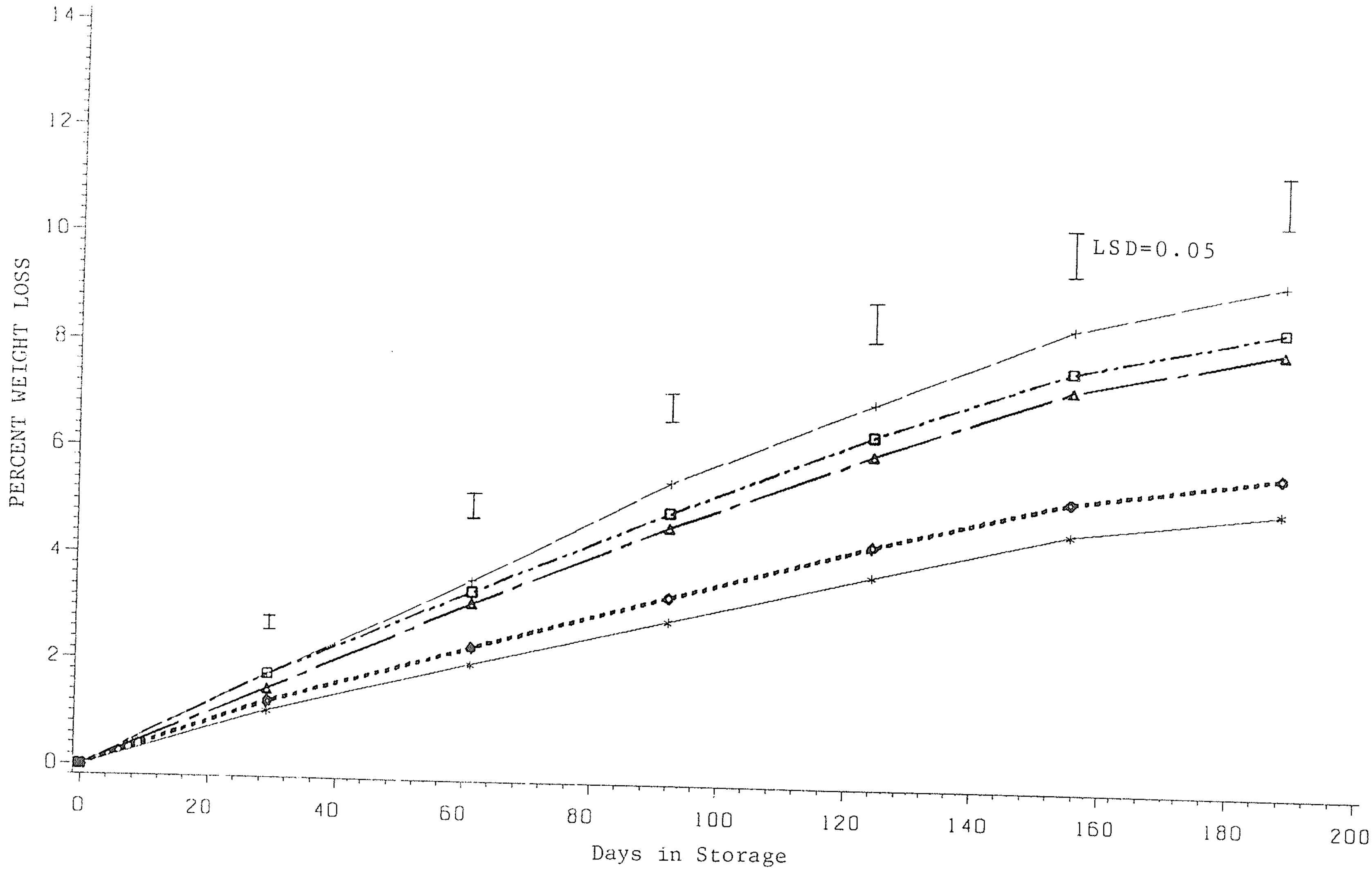

PERCENT WEIGHT LOSS
0
2
4
6
8
10
12
14
LSD=0.05
0
20
40
60
80
100
120
140
160
180
200
Days in Storage

Figure 11: Weight lost in Russet Burbank potatoes during storage in 1983-84 as affected by foliar-applied mefluidide (Aug.24)

Day 0 = Oct. 3, 1983 (Date of initial weight determination)

0.00 kg ai/ha mefluidide

0.25 " " "

0.50 " " "

1.00 " " "

2.00 " " "

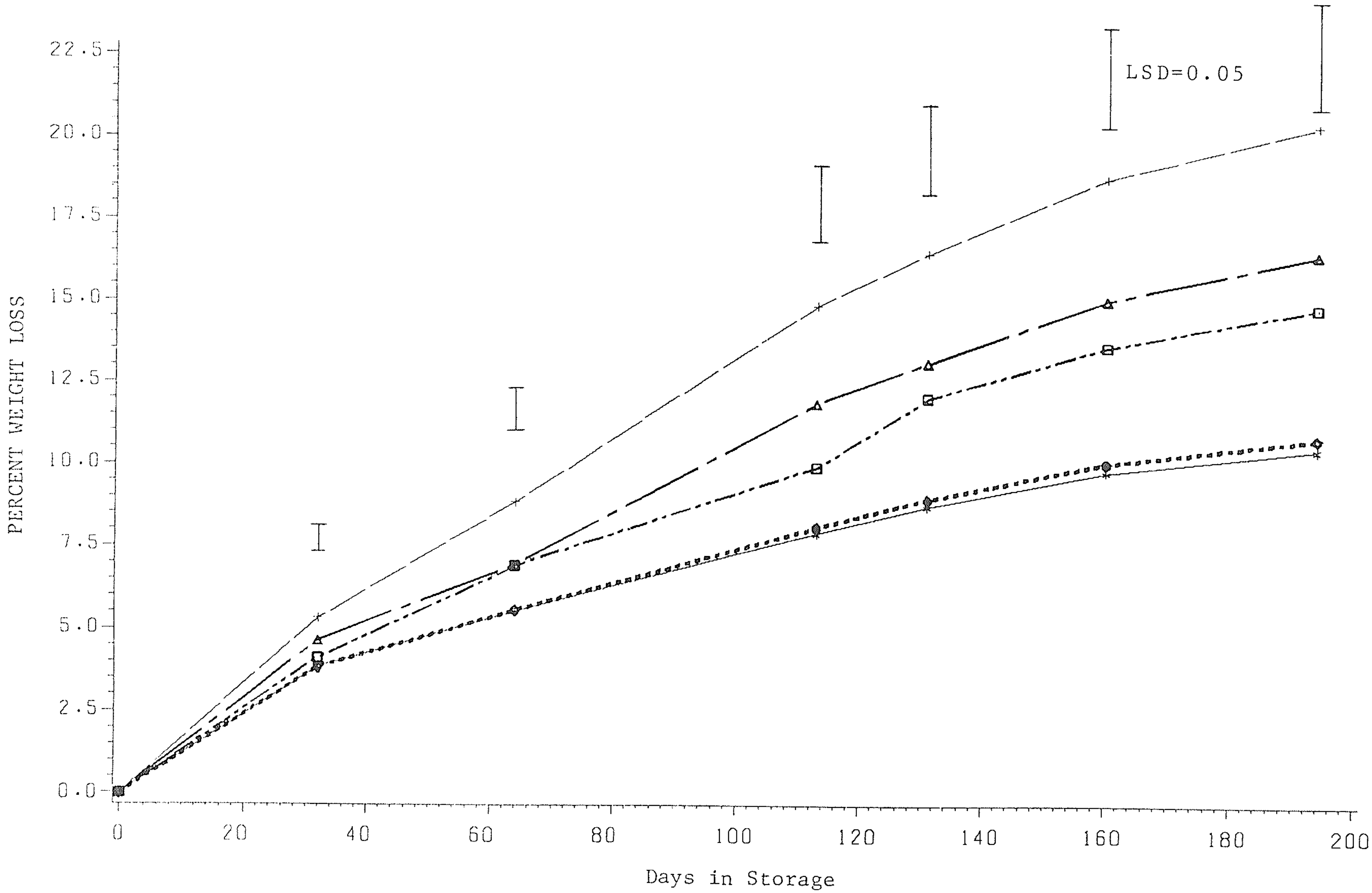

LSD=0.05
PERCENT WEIGHT LOSS
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
22.5
0
20
40
60
80
100
120
140
160
180
200
Days in Storage

Figure 12: Weight lost in Russet Burbank potatoes during storage in 1984-85 as affected by foliar-applied mefluidide (Aug. 15)

Day 0 = Sept. 27 (Date of intial weight determination)

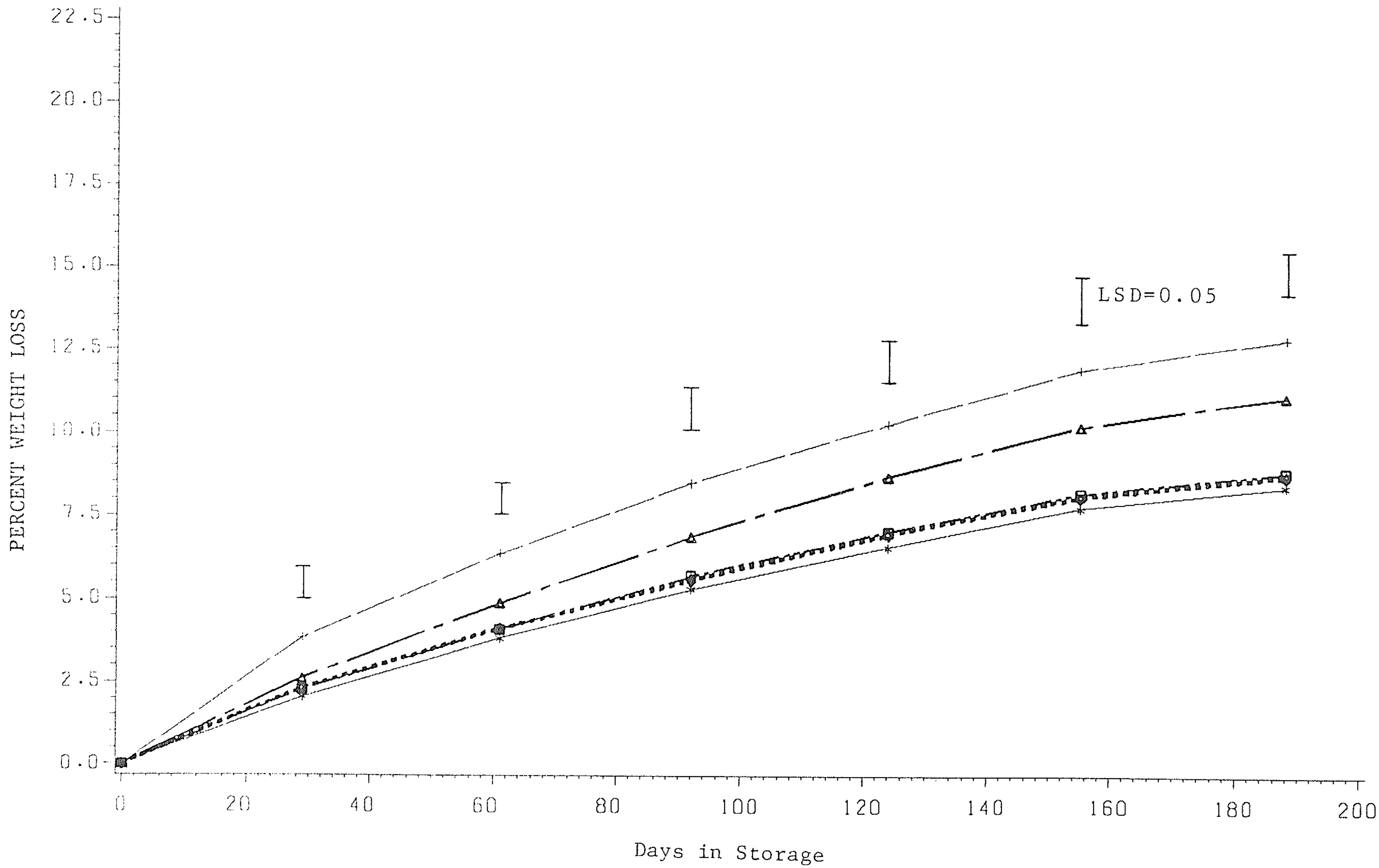
0.00 kg ai/ha mefluidide

0.25 " " "

0.50 " " "

1.00 " " "

2.00 " " "



PERCENT WEIGHT LOSS
22.5
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
LSD=0.05
0
20
40
60
80
100
120
140
160
180
200
Days in Storage

would be true in Norchip. The potatoes harvested in 1983 lost weight at a faster rate than those harvested in 1984.

The rate of weight loss is mostly due to the water lost from the tuber which is influenced by the periderm or skin set (Braue et al., 1983; 1984). The skin set is influenced by the maturity of the potato (Wilcockson, 1981), the soil type (Nielson, 1968), and the curing procedure after harvesting (Braue et al., 1983; Knowles et al., 1982). A better skin develops on potatoes grown on sandy rather than on finer soils, on potatoes where the foliage is beginning to senesce, and in potatoes that have undergone proper curing conditions. In 1984 these condition favored better skin development including the time for curing which was 3 days longer for Norchip and 8 days longer for Russet Burbank than in 1983, ie. the storage temperature was reduced earlier after harvest in 1983 than 1984. The potato foliage was also beginning to senesce earlier in 1984 than in 1983 and the potatoes were grown on sandier soils in 1984. Resistance to water loss not only involves the amount or degree of periderm development but the deposition of suberin in the periderm cell walls (Braue et al., 1984; Kolattukudy and Dean, 1974).

4.7 WEIGHT LOSS DUE TO RESPIRATION

Respiratory loss is the loss of CO_2, or more directly, the loss of carbohydrates from the potato. The estimated respiratory weight loss from the potatoes during the storage period varied from about 10 to 22 g CO_2/kg tuber (or 0.27-0.61% of original tuber weight) depending on the year and cultivar (Tables 7 and 8).

TABLE 7

Respiratory and total weight loss in Russet Burbank during storage as influenced by foliar-applied mefluidide (Aug. 24/83:Aug. 15/84).

Mefluidide kg ai/ha	Resp. wt. loss (g CO_2/kg tuber)	%Resp. wt. loss	%Total wt. loss	%Resp. wt. loss of total wt. loss
		1983-84		
0.00	15.63	0.42	10.50	4.17
1.00	19.41	0.53	16.46	3.21
2.00	22.34	0.61	20.40	2.95
LSD (0.05)	n.s.	n.s.	3.90	0.50
		1984-85		
0.00	10.40	0.28	8.48	3.34
1.00	13.33	0.36	11.19	3.24
2.00	13.91	0.35	10.07	3.52
LSD (0.05)	0.40	0.16	1.75	n.s.

TABLE 8

Respiratory and total weight loss in Norchip during storage as influenced by foliar-applied mefluidide.

Mefluidide kg ai/ha	Resp. wt. loss (g CO_2/kg tuber)	%Resp. wt. loss	%Total wt. loss	%Resp. wt. loss of total wt. loss
		1983-84		
0.00	12.70	0.35	10.89	3.14
1.00	12.81	0.35	12.10	2.88
2.00	13.55	0.37	13.39	2.76
LSD (0.05)	n.s.	n.s.	1.12	n.s.
		1984-85		
0.00	9.79	0.27	5.16	5.29
1.00	10.49	0.29	8.17	3.55
2.00	10.26	0.28	9.43	3.00
LSD (0.05)	n.s.	n.s.	0.96	1.00

Russet Burbank potatoes in 1983-84 and 1984-85 responded to mefluidide which resulted in a higher respiratory loss (Table 7). The higher respiratory loss in the mefluidide treated potatoes gives some indication of the higher total weight loss but the percentage of the total weight loss due to respiration in 1983-84 was lower and in 1984-85 was about the same as in the control. The 1983-84 results for Russet Burbank were determined on just two replicates as opposed to the usual four due to experimental and mechanical error.

Norchip did not show any significant response to mefluidide in respiratory weight loss although there did seem to be a slight trend to suggest it. As in Russet Burbank the mefluidide treatments in 1984-85 lost a lower percentage of their weight loss to respiration. The Norchip control in 1984-85 lost close to 5.3% of its total weight loss to respiration while at 2.00 kg ai/ha of mefluidide the level of respiration accounted for only 3.0% of the loss.

The lower percent respiratory losses for some of the mefluidide treatments indicated that water losses are greater. Water losses are very dependent on the permeability of the potato tuber periderm which is dependent on the suberization of the periderm (Kolattukudy and Dean, 1974; Soliday et al., 1979).

Burton (1978) and Rastovski (1981) state that approximately 0.5-0.6% of the original tuber weight is lost through respiration while respiratory weight loss accounts for approximately 10% of the total weight loss. Their results are rather high compared to this experiment but this may be accountable to different respiration determination methods, environmental conditions, or cultivars.

4.8 SPROUTING IN NORCHIP POTATOES AND COLOR OF PERIDERM IN NORCHIP AND RUSSET BURBANK POTATOES

The degree of sprouting in Norchip potatoes as determined in the spring of 1984 showed some retardation in the growth of the sprouts although the results did not show any significant differences between the treatments (Table 9). There was a general trend for the sprouts to be longer at the lower concentrations of foliar-applied mefluidide than at the higher concentrations. In 1985 the concentrations of mefluidide seemed to have no effect on sprouting.

The periderm color was darker and there was more russetting of the potato periderm as the concentration of foliar-applied mefluidide increased in both Norchip and Russet Burbank potatoes (Table 10). There generally seemed to be a greater affect of mefluidide in 1984 in both Norchip and Russet Burbank than in 1983.

TABLE 9

Degree of sprouting in Norchip potatoes in the spring of 1984 and 1985 as affected by foliar-application of mefluidide

	1984			1985		
	Sprout Length			Sprout Length		
Mefluidide kg ai/ha	1-5mm	5-15mm	>15mm	1-5mm	5-15mm	>15mm
0.00	60%[1]	25	10	75	10	0
0.25	65	30	5	80	15	5
0.50	65	35	0	75	10	10
1.00	70	15	5	85	10	0
2.00	75	20	0	75	15	0
LSD (0.05)	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

[1]Total percentages may not equal 100% because some of the potatoes had not sprouted.

TABLE 10

Changes in the periderm color of Norchip and Russet Burbank potatoes in 1983 and 1984 influenced by foliar-application of mefluidide

	Norchip		Russet Burbank	
Mefluidide kg ai/ha	1983	1984	1983	1984
0.00	1.00[1]	1.25	1.00	1.13
0.25	1.50	1.50	1.63	1.88
0.50	2.23	2.38	2.13	2.36
1.00	3.25	3.38	3.38	3.88
2.00	4.50	4.75	4.63	4.87

[1]Color of periderm is graded 1 to 5. 1 being normal (white and smooth) and 5 being dark brown and russetted.

4.9 YIELD, PROCESSING QUALITY, AND STORAGE CHARACTERISTICS OF RUSSET BURBANK POTATOES FOLIAR TREATED WITH MEFLUIDIDE ON TWO DIFFERENT DATES

Late application of mefluidide compared to the early application had no significant impact on yield (Table 11) but in 1983 there was a slight reduction in the marketable and total yields while there was an increase in deformed potatoes. The data for the different application dates is the average of all the the mefluidide rates. Late application of mefluidide had the effect of reducing marketable yield by about 20% and increasing the percent deformed potatoes by close to 10%. In 1984 any differences between the two application dates were very slight. The specific gravity differed little in either year but there was a tendency to increase specific gravity with the late application of mefluidide (Table 12). Also the potatoes treated with the late application of mefluidide had a darker and more russetted periderm than its early counterpart (Table 13).

The response of sucrose levels (SR) to different dates of application of mefluidide are shown in Figures 13 and 14. In 1983-84 the late application sample had a higher, although not significantly higher, SR value for most of the storage period until the final month when the values were similar. In 1984-85 the SR values were very similar throughout the storage period until March when the late application SR was lower than the early application.

Respiration levels were higher in the potato tubers that received the late application of mefluidide for most of the storage period in 1983-84 (Figure 15). The differences were greater at the beginning and end of

TABLE 11

Effect of mefluidide application time on Russet Burbank yields (per 9m row).

Application Time	Marketable (#)	Marketable (kg)	Deformed (#)	Deformed (kg)	%Deformed Potatoes	Total Yield(kg)
---- 1983 ----						
Early(Aug.10)	22.95	3.94	23.30	4.55	51.35	17.57
Late(Aug.24)	18.55	3.03	26.35	4.29	61.80	16.31
LSD (0.05)	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
---- 1984 ----						
Early(Aug.1)	84.56	17.00	1.76	0.69	2.08	25.27
Late(Aug.15)	83.78	16.25	1.31	0.44	1.61	24.09
LSD (0.05)	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

TABLE 12

Effect of mefluidide application time on Russet Burbank specific gravities

Application Time	1983	1984
Early(Aug.10/83;Aug.1/84)	1.0629	1.0945
Late(Aug.24/83;Aug.15/84)	1.0634	1.0947
LSD (0.05)	n.s.	n.s.

TABLE 13

Effect of mefluidide application time on periderm color of Russet Burbank potatoes.

Application Time	1983	1984
Early(Aug.10/83;Aug.1/84)	2.23[1]	2.50
Late(Aug.24/83;Aug.15/84)	2.55	2.85

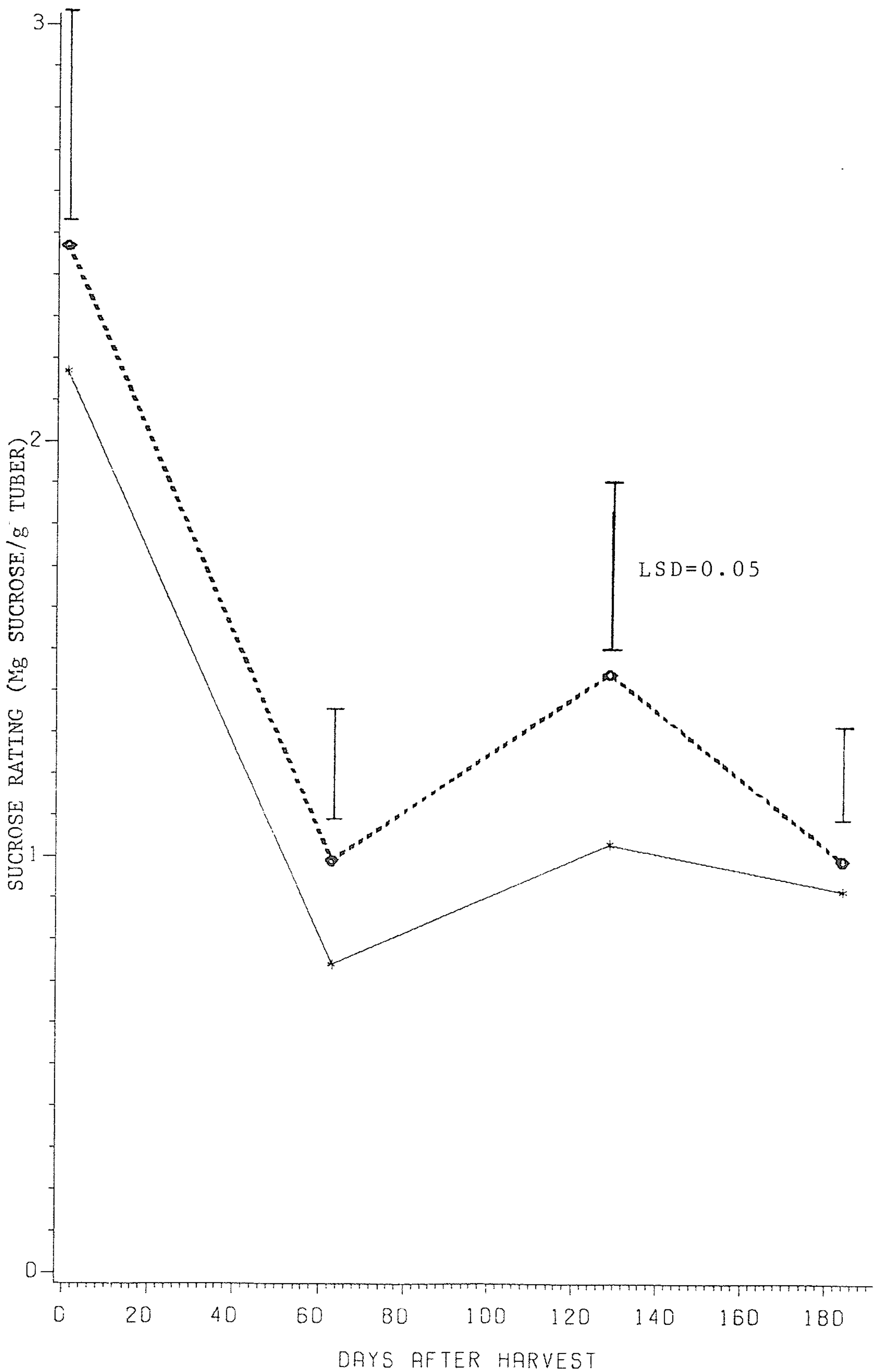
[1]Color of periderm is graded 1 to 5. 1 being normal (white and smooth) and 5 being dark brown and russetted.

Figure 13: Changes in the sucrose ratings in Russet Burbank potatoes after harvest and during storage in 1983-84 as influenced by different application dates of mefluidide

Day 0 = Sept. 23, 1983.

Early application (Aug.10, 1983)

Late " (Aug.24, 1983)



3
2
1
0
SUCROSE RATING (Mg SUCROSE/g TUBER)
LSD=0.05
0
20
40
60
80
100
120
140
160
180
DAYS AFTER HARVEST

Figure 14: Changes in the sucrose ratings in Russet Burbank potatoes after harvest and during storage in 1984-85 as influenced by different application dates of mefluidide

Day 0 = Sept. 19, 1984.

Early application (Aug. 1, 1984)

Late " (Aug.15, 1984)

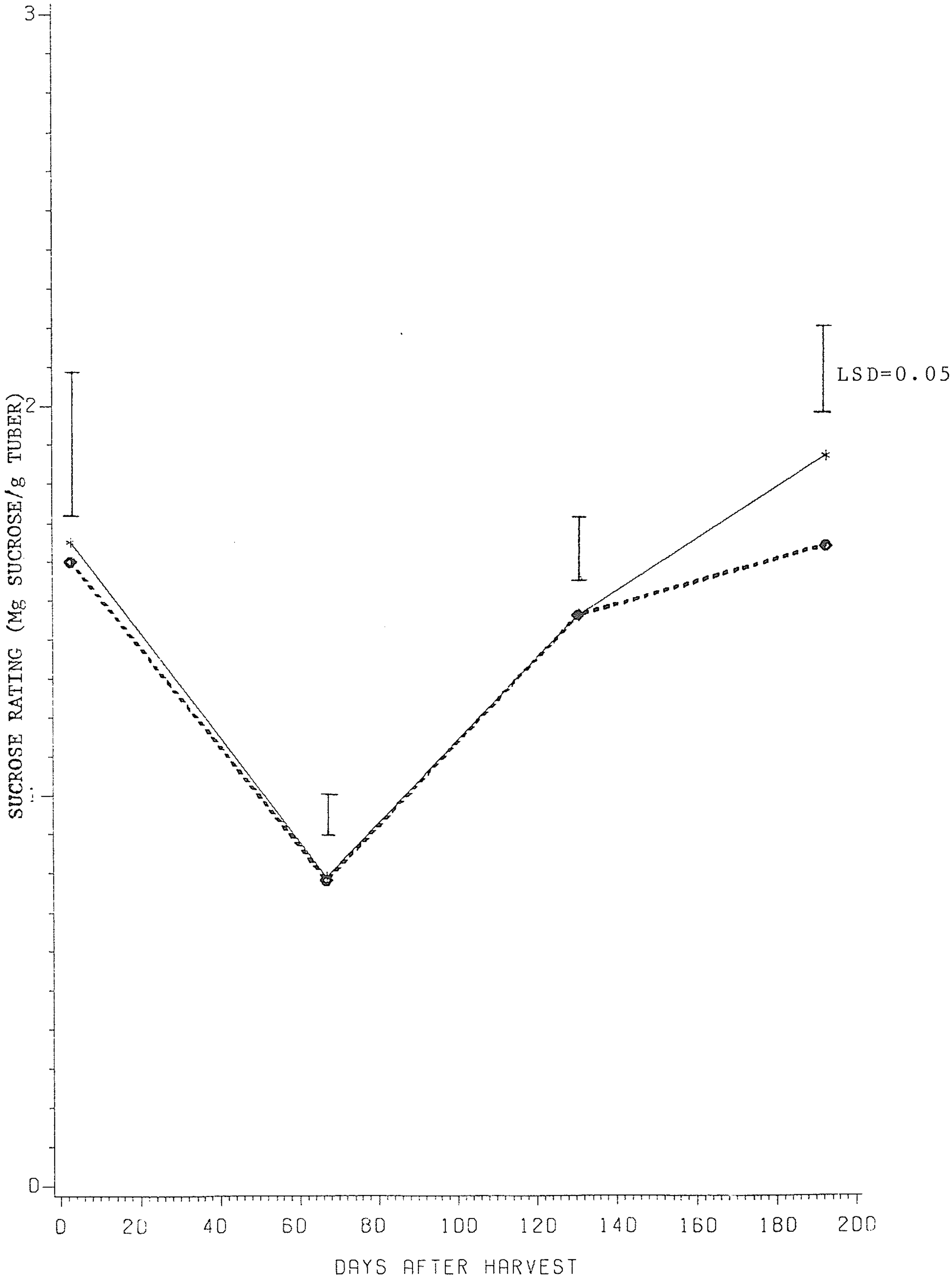
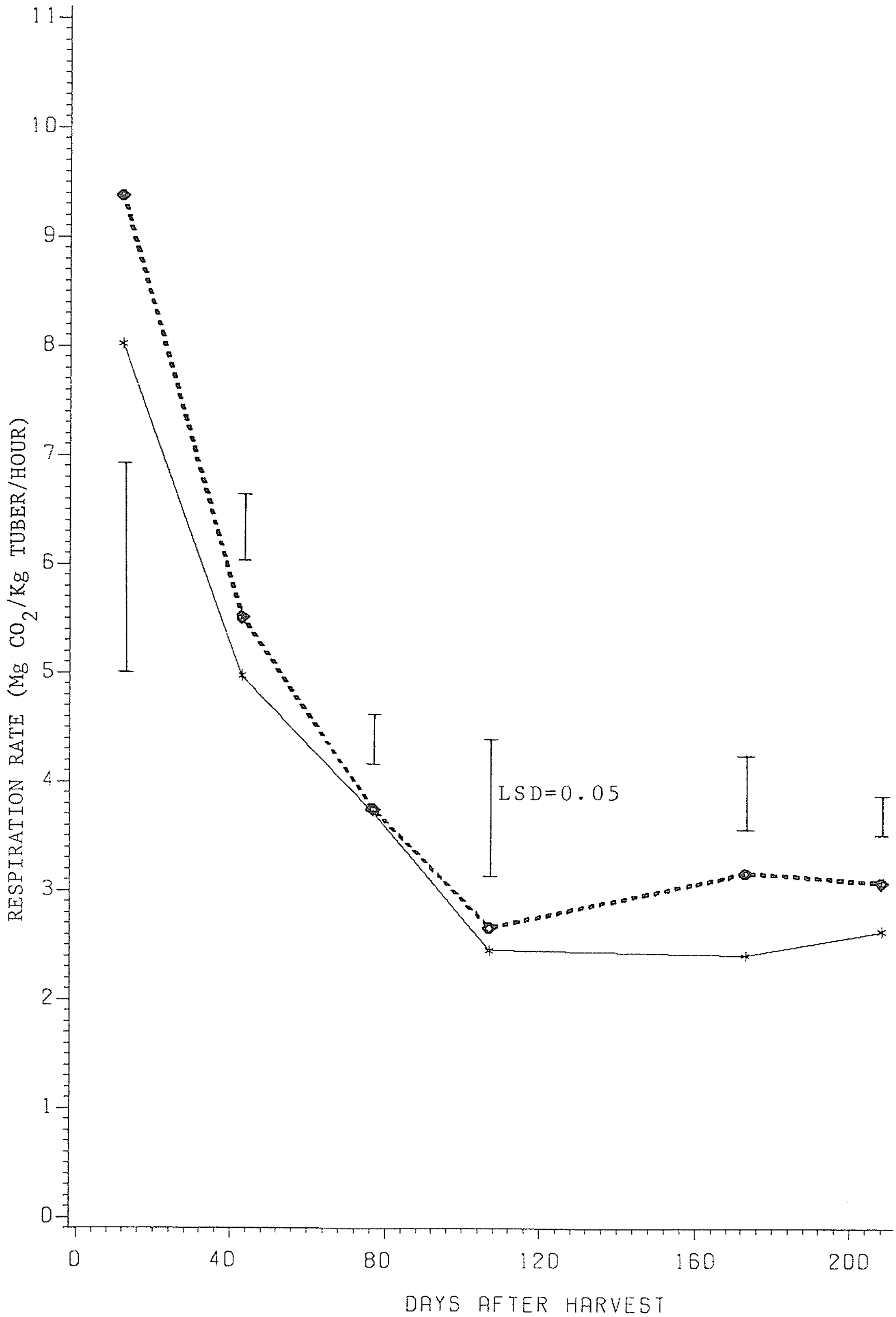

SUCROSE RATING (Mg SUCROSE/g TUBER)
3
2
1
0
LSD=0.05
0
20
40
60
80
100
120
140
160
180
200
DAYS AFTER HARVEST

Figure 15: Effect of different application dates of mefluidide on the respiration rates in Russet Burbank potatoes after harvest and during storage in 1983-84.

Day 0 = Sept. 28, 1983.

Early application (Aug.10, 1983)

Late " (Aug.24, 1983)



RESPIRATION RATE (Mg CO_2/Kg TUBER/HOUR)
11
10
9
8
7
6
5
4
3
2
1
0
LSD=0.05
0
40
80
120
160
200
DAYS AFTER HARVEST

Figure 16: Effect of different application dates of mefluidide on the respiration rates in Russet Burbank potatoes after harvest and during storage in 1984-85.

Day 0 = Sept. 19, 1984.

Early application (Aug. 1, 1984)

Late " (Aug.15, 1984)

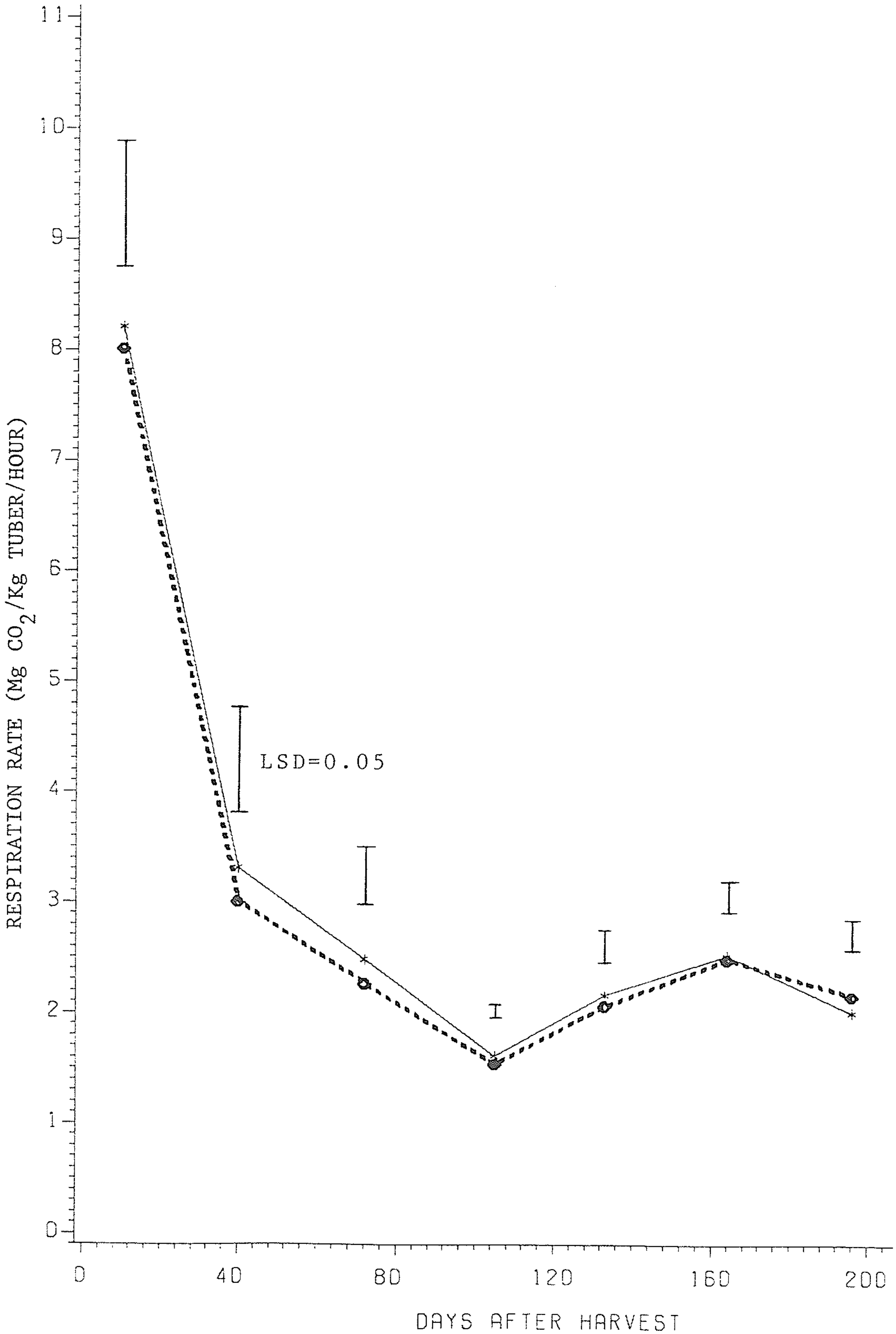
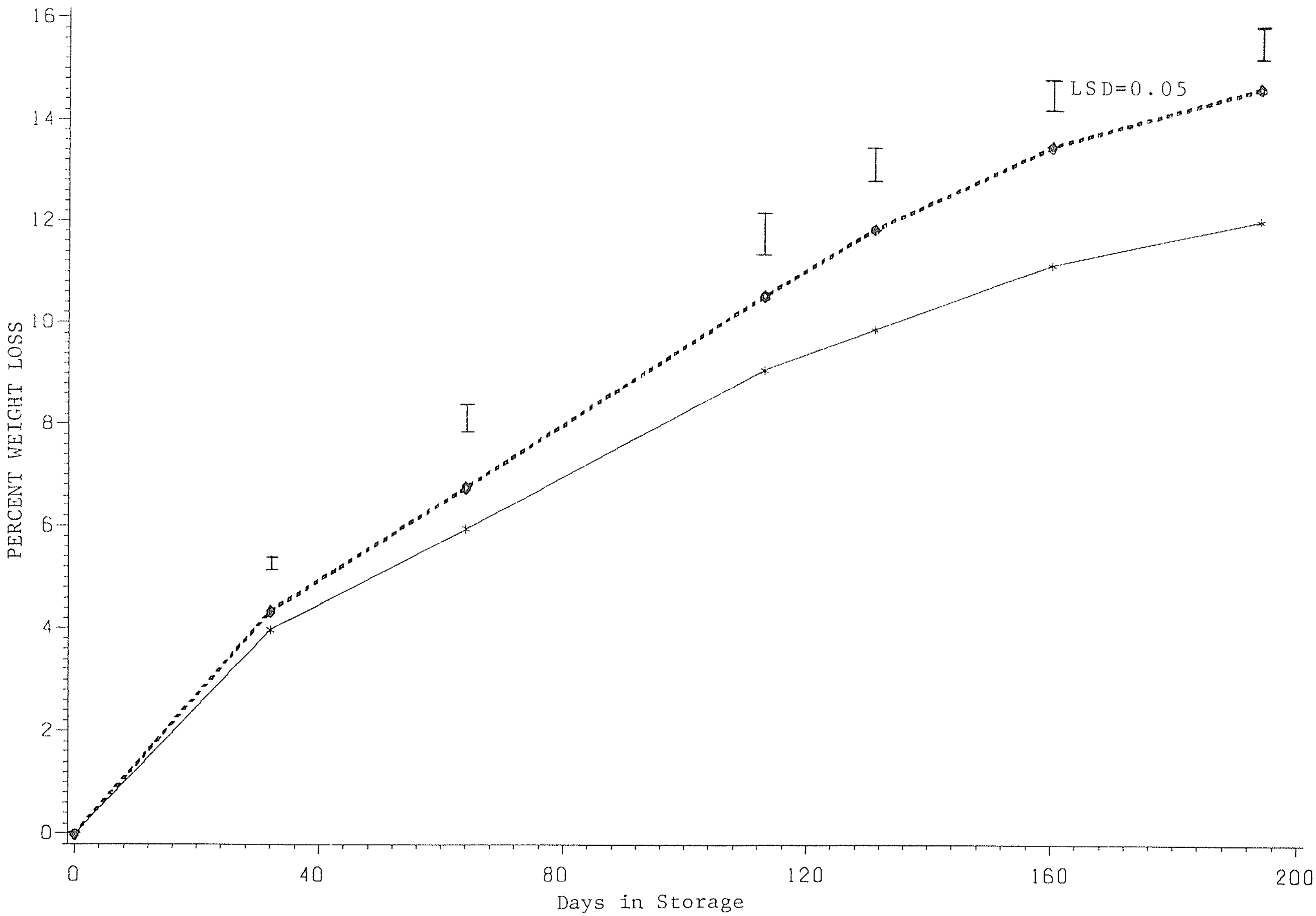

RESPIRATION RATE (Mg CO_2/Kg TUBER/HOUR)
11
10
9
8
7
6
5
4
3
2
1
0
LSD=0.05
0
40
80
120
160
200
DAYS AFTER HARVEST

Figure 17: Weight loss in Russet Burbank potatoes during storage in 1983-84 as influenced by different application dates of mefluidide

Day 0 = Oct. 3 (Date of initial weight determination)

Early application (Aug.10, 1983)

Late " (Aug.24, 1983)



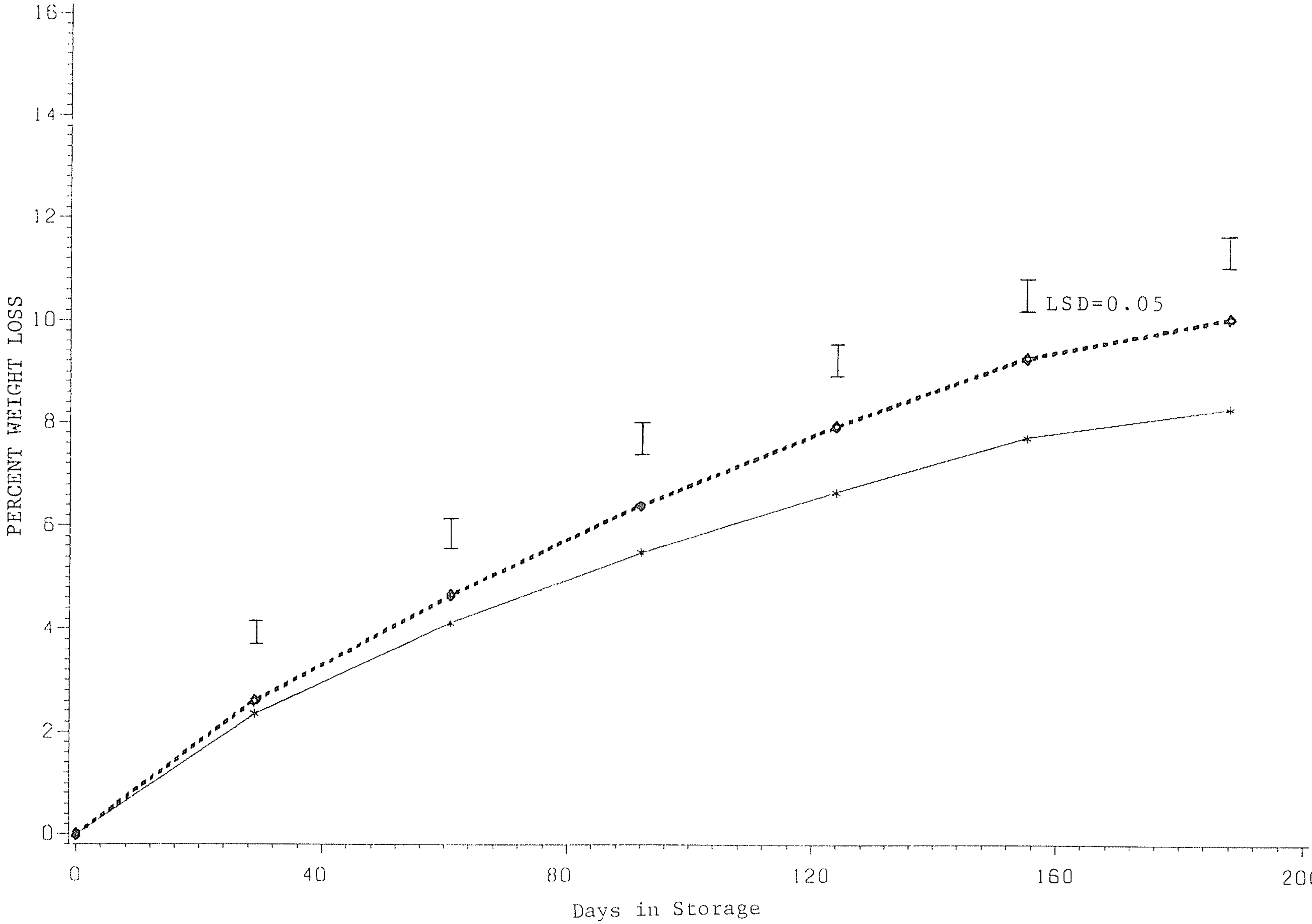
PERCENT WEIGHT LOSS
0
2
4
6
8
10
12
14
16
LSD=0.05
0
40
80
120
160
200
Days in Storage

Figure 18: Weight loss in Russet Burbank potatoes during storage in 1984-85 as influenced by different application dates of mefluidide

Day 0 = Sept. 27, 1984 (Date of initial weight determinatio)

Early application (Aug. 1, 1984)

Late " (Aug.15, 1984)



PERCENT WEIGHT LOSS
0
2
4
6
8
10
12
14
16
LSD=0.05
Days in Storage
0
40
80
120
160
200

storage. In 1984-85 there was little response to different application dates (Figure 16).

Early application of mefluidide resulted in lower weight losses in both years (Figures 17 and 18). The overall weight losses were greater in 1983-84 but the percent differences in losses between early and late application were about the same for both years, around 20% greater losses in late over early. Respiratory losses were greater for the late application of mefluidide than the early in 1983-84 (Table 14) but in 1984-85 the results were similar.

4.10 GROWTH ROOM STUDIES ON NORCHIP POTATOES

Application of mefluidide to 2 week old plants in the controlled environment conditions affected the shoot apical meristem and some of the young leaves but did little as far as affecting the fresh and dry weights of foliage and roots (Table 15). There is, however, a trend in the tubers for a reduction of 10% in fresh weight and dry weight, and a slight reduction in dry weight percentage. Approximately 1 week after mefluidide application there was an affect on the developing new leaves. The leaves were somewhat deformed, crinkly, and the leaf margins of the younger leaves became necrotic. Two weeks later the shoot apical meristem and the new leaves once again grew normally.

Application of mefluidide to the 2 month old plants did not have any significant affect on the potatoes (Table 16) except to alter the color and russeting of the periderm. The color of the periderm became darker and the normally smooth skin became more russetted with increased con-

TABLE 14

Respiratory and total weight loss in Russet Burbank during storage as influenced by foliar application of mefluidide on two different dates.

Application Time	Resp. wt. loss ($g\ CO_2/kg$ tuber)	%Resp. wt. loss	%Total wt. loss	%Resp. wt. loss of total wt. loss
		1983-84		
Early(Aug.10)	15.90	0.43	12.01	3.20
Late(Aug.24)	19.22	0.52	14.61	3.82
LSD (0.05)	2.41	0.07	0.80	n.s.
		1984-85		
Early(Aug.1)	12.82	0.35	8.31	4.24
Late(Aug.15)	12.22	0.33	10.07	3.11
LSD (0.05)	n.s.	n.s.	0.67	0.27

TABLE 15

Effect of mefluidide on two week old Norchip potatoes grown in nutrient solution

Mefluidide (mg/l)	Foliage Plant Ht.(cm)	Foliage FW (g)	Foliage DW (g)	Foliage %DW	Root FW (g)	Root DW (g)	Root %DW	Tuber FW (g)	Tuber DW (g)	Tuber %DW	Tuber Stolon & Tuber No.
0.00	14.0	32.7	3.5	11.0	6.9	0.6	7.4	68.1	13.6	19.9	4.9
0.05	14.0	31.3	3.2	10.3	6.3	0.5	7.0	64.8	12.6	19.7	4.6
0.10	14.0	32.0	3.4	10.8	6.2	0.4	6.9	63.9	12.7	19.7	4.7
0.20	14.2	35.5	3.9	11.2	6.4	0.5	6.9	61.1	11.8	18.9	5.6
LSD (0.05)	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

TABLE 16

Effect of mefluidide on two month old Norchip potatoes grown in nutrient solution

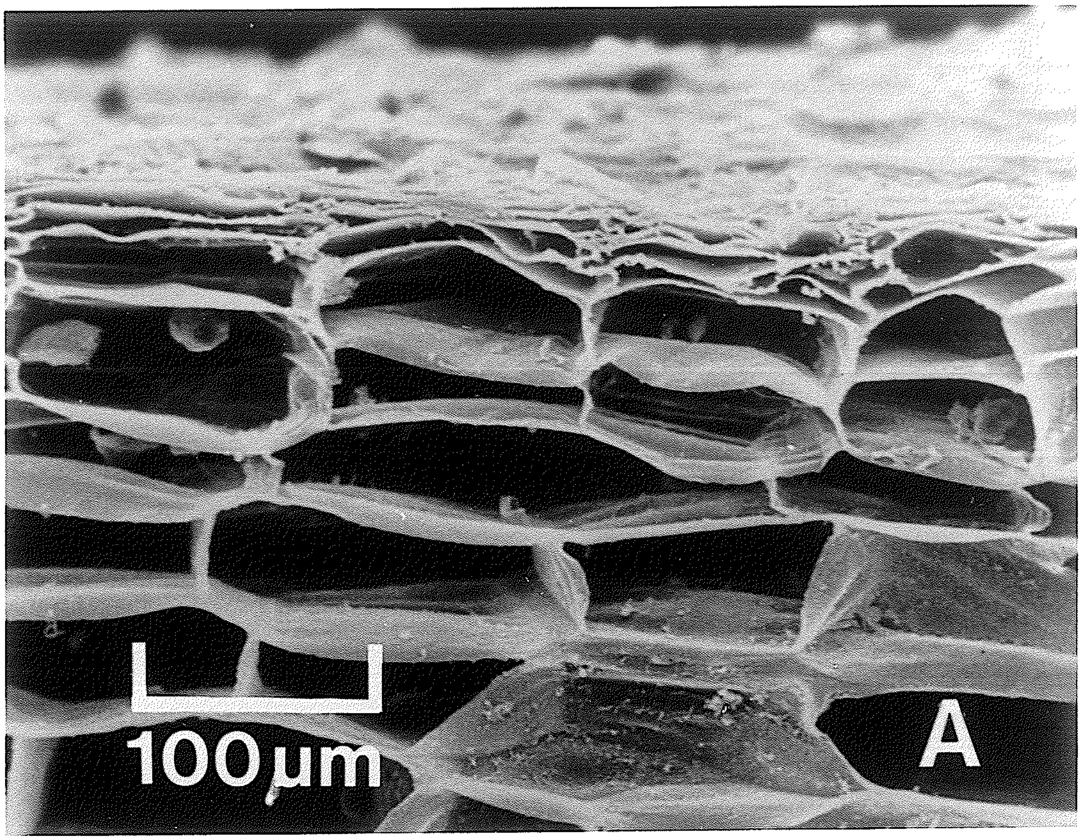
Mefluidide (mg/ml)	Foliage FW (g)	Foliage DW (g)	Foliage %DW	Tuber FW (g)	Tuber Stolon & Tuber No.	Tuber Color of Periderm[1]
0.00	181.2	16.6	9.2	400.3	5.8	1.5
0.05	155.6	17.0	10.9	365.9	4.5	2.0
0.10	158.0	14.2	10.4	358.1	5.5	2.8
0.20	145.8	15.3	10.6	345.4	7.8	4.5
LSD (0.05)	n.s.	n.s.	n.s.	n.s.	n.s.	

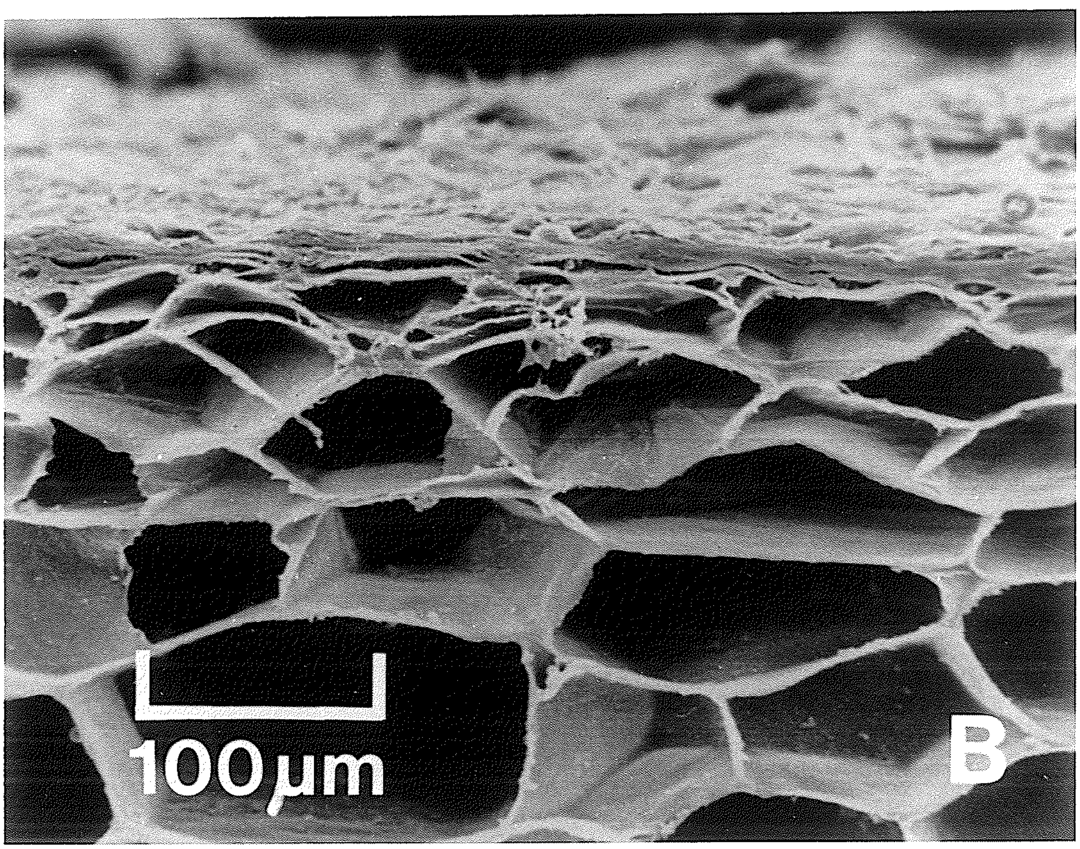
1. Color of periderm is graded 1 to 5. 1 being normal (white and smooth) and 5 being dark brown and russetted.

Figure 19: Scanning electron micrograph of the effect of mefluidide on the periderm of Norchip potatoes grown in nutrient culture.

A = foliar application of 0.00 mg/ml.

B = " " " 0.20 mg/ml.


100 µm
A


100 µm
B

centration of applied mefluidide. The fresh weight of both the foliage and the tubers did decrease by about 20% and the percent dry weight of the foliage increased but these results were not significant.

Scanning electron micrographs of the periderm (Figure 19) show that there may be an affect of mefluidide on the structure of the periderm cells. The periderm cells are normally in nicely orientated files (Figure 19a) (van Es and Hartmans, 1981a) but it appears as if this is not as nicely defined in the tuber periderm treated with mefluidide (Figure 19b).

Chapter V

GENERAL DISCUSSION

The results from the above experiments are neither complete nor conclusive in showing the detrimental or beneficial effects of mefluidide on potato production, storage, or processing. It does appear, however, that the benefits may only be few and the economic value to the crop is probably negative. In the critical area of yield there was no indication of improved production with the application of mefluidide with the possible exception with Norchip at the 0.25 kg ai/ha. In Russet Burbank there is a clear indication that visible quality of the potato tuber can be affected by mefluidide as attested to the fact that there were increased deformities and a lower marketable yield in 1983-84. In the same year total yields in Russet Burbank were only slightly affected. Other work with growth retardants on potatoes have come up with both similar and contrary results. Dyson (1965) indicated that there was no affect on total yield of potatoes treated with cycocel. Radwan et al. (1971), however, showed that yields could be increased with application of cycocel. The conclusion by Radwan et al. (1971) was that cycocel affected the carbohydrate metabolism of the treated plants. Any such conclusions concerning mefluidide's action on potatoes would be presumptuous, but its affect on specific gravity could be some indication that this may indeed be a possibility.

Mefluidide slightly increased specific gravity and improved chip color in Norchip and possibly specific gravity in Russet Burbank. Since Russet Burbank and Norchip are extensively used in processing, a high specific gravity is desirable. High specific gravity is often associated with light chip color and high processing yields (Hyde and Shewfelt, 1960). These attributes may signify the only positive affects of mefluidide.

Mefluidide affected the sucrose levels in Norchip before harvest to some degree by slowing the loss of sucrose during maturation. Zulu (1983) noted the same results. This was only a temporary development as by harvest there was no real differences between the control and mefluidide treated potatoes. The sucrose rating (SR) generally declined after the preharvest foliar treatments of mefluidide, rose slightly just before harvest, and then increased after about two months into storage. In 1983-84 there was a major decrease at the end of the storage period. For both years the SR results were fairly variable in Norchip but there was a slight trend for the SR value to be lower at the 0.00 and 0.25 kg ai/ha levels of mefluidide. In Russet Burbank the control consistently had lower sucrose levels during storage and the sucrose content usually increased with the increase in the concentration of foliar applied mefluidide. The SR in Russet Burbank decreased during the first month, increased in the following month and then either continued to increase at the end of the storage period as in 1984-85 or decreased as in 1983-84. The reason for the difference in behavior at the end of the storage period for the two years is unknown but it could relate to the two known types of sugar accumulation, namely cold-induced and senescent sugar accumulation (Isherwood, 1976).

The reason for an increase in the SR in response to mefluidide is open for speculation. It may be a stress factor that would be equivalent to other physiological stresses such as drought or high temperatures (van Es and Hartmans, 1981b; Shektar et al., 1979). This may all be related to an affect at the membrane level where, it is hypothesized, the levels of sugars and starch are controlled (Isherwood, 1976).

Respiratory activity in the potato tubers was increased in response to mefluidide, especially towards the end of the storage period. In Norchip there was a tendency for mefluidide to suppress respiration in the first month of storage. Russet Burbank potatoes responded to mefluidide in a similar manner to Norchip except the response was throughout the storage period not just at the end of the storage period.

An increase in respiration is of some concern in storage. Increased respiration increases weight loss, although this is minimal compared to water loss, and it also would increase the level of CO_2 in storage. Unchecked increases in CO_2 levels is of concern to producers because of the negative consequences it can have on the processability of potatoes such as increased sugar content and darker potato chip color (Shamaila, 1985) and an increased incidence of disease (Workman and Twomey, 1970).

Potatoes lost weight at a faster rate in response to mefluidide and most of this could be attributed to the loss of water from the tuber. Water loss though the periderm is dependent on its maturation (Burton, 1978) and on the suberization of the periderm cell walls (Kolattukudy and Dean, 1974). It is therefore possible that mefluidide could affect the amount of suberization, the chemical components of the suberin, or the orientation and development of the periderm cells. In the growth room studies it appears likely that mefluidide may affect the periderm development. Any effect of mefluidide on the amount of suberization or its composition would have to be determined by extensive chemical analysis or by microscopy.

The weight loss due to respiration was greater in the potatoes treated with mefluidide. The percentage of the total weight loss due to respiration, however, was usually smaller in the mefluidide treated potatoes which indicates that most of the additional weight loss was due to an increase in water losses from the tuber.

Russet Burbank potatoes treated with mefluidide on two different dates indicated that the later treatment, compared to the earlier treatment, has a greater impact on sucrose content, respiration, weight loss, and periderm development. Late application of mefluidide tended to increase the sucrose content, the rate of respiration, weight loss, and the periderm darkened and became more russetted. Also in 1983 the late application also reduced the marketable yield.

Growth room studies were generally inconclusive but there is some indication that there may be a negative impact of mefluidide on the fresh and dry weights of the tubers, and the percent dry weights. In both the growth room and field studies the periderm changed from a smooth white color to a russetted dark brown.

In conclusion, in this study on potatoes it was found that mefluidide usually had little or no influence on yield in the field work, may have an influence in sucrose content (depending on the cultivar), increases the respiratory activity, and increases the weight loss in the potato tubers during storage. Growth room studies indicated that there may be a possibility that tuber yields decrease in both fresh weight and dry weights, and that the periderm development may be affected in response to mefluidide.

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