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CULTURAL AND MARKETING STUDIES ON DILL, *ANETHUM GRAVEOLENS* L.

A Thesis Presented

by

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Thank you to my advisor Lyle E. Craker who made this quite a learning experience. Thanks to Allen V. Barker and Stephen J. Herbert for their words of wisdom.

DEDICATION

Ones life is filled with many "chapters", some short and some happier than others. I am glad this ardous chapter has finally come to an end.

To my family: Shirley, Bob, Gail, Robert and Elizabeth who were always there with their support and those needed words of encouragement.

To my very special friends who understood, and for their pep talks when I was too frustrated to want to continue .....THANKS!!

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CHAPTER I

INTRODUCTION

To remain viable, agriculture in Massachusetts should seek and identify new crops and markets in which the return for agricultural produce is economically profitable to the grower. Herbs, spices, and medicinal plants, specialty crops and generally command higher prices than traditional crops, could be adapted to the small fields and marginal land of the Massachusetts farmer. Herbs and spices generally have lower production and harvesting costs than comparable traditional crops. The relative production and harvesting costs for catnip and peppermint leaf was on the average of $48.00/ha as compared with $531.00/ha for cucumbers and $105.00/ha for sweet corn in 1983 (34).

Currently, the United States is the world's largest importer of herbs and spices, importing 195,855 metric tons of this plant material valued at 271.3 million dollars in 1984 (42). At present, much of the imported material lacks homogeneity and cleanliness, requiring additional, expensive processing steps (28). In addition, imported herbs often are subjected to fumigation and sprayed with pesticides that are restricted or banned in the United States. Low levels of DDT and BHC were detected consistently in plant tissue of imported herbs in a

study conducted by the American Spice Trade Association (14). This presents a problem to those wholesalers and consumers seeking herbs and spices free of pesticides.

Domestic production of herbs and spices currently account for slightly over one-third of the United States requirements (42). Although the domestic herb and spice industry is under market competition from lower priced imports (43), domestically produced herbs and spices usually are of a higher quality and are more readily available for distribution (43). Additional marketing opportunities would be available for herbs grown organically.

There is growth and marketing potential for herbs and spices grown in the United States. The American Trade Association reports that the United States consumption of herbs and spices continues to increase faster than the growth of the population (41). United States food processors, pharmaceutical houses, and retail outlets require large amounts of quality herbs for the products they produce or sell (28). Given the increase in the use of herbs and spices, coupled with the amount of material being imported, regional growers producing herbs and spices of high quality can expect excellent markets for their crops.

Due to the competitive market and traditionally secretive nature of the U.S. herb industry (38), commercial producers of herbs and spices generally do not publish nor share their cultural practices, sources of plant material, and harvesting or processing techniques. Therefore, studies on optimum plant spacing and row widths, fertilizer requirements, herbicide recommendations, product processing, and the

development of markets are lacking. Before herbs can become a successful and economically viable crop for the commercial grower, production and cultural studies are warranted. This study was conducted to identify problems associated with the herb industry and to develop cultural recommendations for the commercial production of dill in the Northeast.

Dill, Anethum graveolens L., was selected for use in this study because of its different herbal utilization and growth characteristics and for its adaptability for production in the Northeast United States. As an annual plant, dill is used as a culinary and medicinal herb. Fresh or dried leaves are used in sauces, dressings, soups and salads, and for seasoning of poultry, fish, seafood, meats, and eggs. Seeds are used to flavor pickles, gravies, and breads (33). Medicinally, dill is utilized as a diuretic, antispasmodic, or glactogogue (18). Dill is a member of the largest herb family, Umbelliferae.

CHAPTER II

LITERATURE REVIEW

The majority of research on herbs and spices is conducted outside the United States and in European and Asian countries (2,9,20,21,23,24,25,26,39). Due to climatic differences between the United States and Europe, much of the research on herbs and spices can be used only as a guide for production of these crops in the United States. Of the available United States guides for growing herbs and spices, few are based on field trials (4,8,10,29,33,37), and many are outdated (40,44,45,46). Because of the lack of current cultural recommendations and lack of sharing of information, today's farmers find themselves spending valuable time and money investigating the optimum planting density, fertilizer rates, herbicides rates, and markets.

Planting Recommendations

No studies on dill were reported that investigated the effect of varying row widths and plant spacing on foliar yields. Of the research specifying a row width and a plant spacing utilized, most were studies on seed yields and oil quality with no mention of foliar yields (12,20,21,26). Other studies stated the row width used with no

mention of the plant spacing (6,9). Zlatex (50) investigated row widths of 12.5, 25, 50 cm and observed that the highest green plant yield of dill was at 25 cm row width with no mention of the plant density. He stated that the foliar yields at 25 cm row width were 13% and 34% higher compared with the plants grown at 12.5 and 50 cm row widths respectively. Zlatev said that the greatest stem height and oil content was attained at 25 cm row width. Row width recommendations for dill vary from 20 to 45 cm (5,9,11,12,20,21,26) and plant spacing of 10 to 20 cm (5,6,12,20,26).

Fertilizer Applications

Many popular growing guides in the United States advocate the use of compost and organic fertilizers and state that inorganic fertilizers cause unwanted, lavish growth with a loss of flavor in the leaves and fruit (7,15,18,22,29,35,36,44). Researchers have observed that the addition of organic or inorganic fertilizers increase plant and seed yields and the quality of the essential oils (2,9,21,23,24,25,26). Higher yields are the result of increased number of branches per plant, increased foliar weight per plant, increased number of umbels, and increased number of seeds per plant (9,21,23,24,25,39).

Fertilizer applications for dill are suggested for before sowing and as a side-dressing (9,21,26). Duhan (9) applied half of the total nitrogen as urea at the time of sowing and the remaining half as a top dressing approximately 2 months following the initial application. Gupta (21) applied a second application of nitrogen in the form of

calcium ammonium nitrate as a top dressing one month after thinning. Hornok (25) used a leaf-mold containing N-effective agent and doubled the essential oil content.

Hornok's (24) experiment included 4 levels of N, P, K but did not state what the levels were or when the fertilizer was applied. However the study did establish that different levels of nitrogen and phosphorus should be applied to dill depending on whether the crop is to be marketed as oils, seed, or foliar. He observed that increasing levels of phosphorus decreased the essential oil content in dill weed but did not affect that of the dill seed (24,25). Hornok concluded that nitrogen had the main effect on the essential oil yield of dill weed without umbels and that phosphorus had a major role in influencing the essential oil content of dill seed. The level of potassium supplied did not appear to influence oil content or composition (24). Potassium did influence the foliar and seed yield but to a lesser degree than nitrogen and phosphorus. Atanassou et al (2) concluded that the greatest foliar yield was obtained with a rate of N 70, P 70, K 70 kg/ha with the higher fertilizer levels of 140 kg/ha not enhancing the foliar yield. In a 1983 study, Hornok (23) reported that the highest level of nitrogen, 240 kg/ha, decreased foliar yields. Hornok concluded that the foliar yield increased proportionally as the levels of N-supply increased to a point at which yields decreased.

Duhan et al (9) reported that dill should be fertilized with 90 kg N/ha or at least 60 kg N/ha for maximum seed yields. Seed yield increased with each increase in nitrogen level when compared with the

control: 30 kg N, 8%; 60 kg N, 26%; 90 kg N, 52%. Investigators have observed that nitrogen had no effect on the quality of essential oil in dill seed but had a linear effect on seed yield as the nitrogen levels increased (9,23,24,39). Singh (39) and Hornok (23) demonstrated that N did not significantly affect seed yields contrary to Duhan's findings. This result may be due to the differences in the highest nitrogen levels. Both concluded that nitrogen significantly affected the seed yield per plant.

Essential Oils

Essential oils, carvone, limonene, and phellandrene, are natural substances that determine the fragrance of dill. They are used widely in perfumes, cosmetics, food flavorings, liquers, and medicines (19,22). The marketing price of dill is determined by the percentage of carvone. Carvone content should not be less than 30% of the total oils to be at the minimum level of acceptance as good-quality oil (6,11,20,26). Chubey and Dorell (6) reported that dill oil from test plots averaged 37.3 % carvone if harvested at a stage when 50% of the umbels had turned amber color. The essential oil concentrations vary according to the genetics of the plant, and the geographical region as well as with the time of harvest, methods of harvest, fertilizers applied, and distillation techniques (9,22). Duhan *et al*. (9) demonstrated that different dates of sowing affect the percent carvone content in dill oil. This response was thought to be due to the fact that some plants had comparatively more time for their vegetative growth. It was concluded that the atmospheric temperature should be

at least 32 F at sowing. Laboratory distillation of essential oils from the plant material is necessary to evaluate yield and quality (19,20).

Marketability

Time to harvest dill depends on how the crop will be marketed. Dill is marketed in 4 ways: as dill weed (fresh or dried), as dill weed with umbels (fresh or dried), as dill weed and dill seed oils, and as dill seeds. Dill weed and dill weed oil are harvested when the plant is in the vegetative stage prior to the umbels starting to mature (20,22). Dill weed with mature umbels is marketed at maximum plant height while the seeds are green. The time to harvest dill seed is when the fruit changes from a darker green to gray in color and the maximum number of umbels are ripe (3,12,20). The quality of dill oils depends on the maturity of the herb and seeds as well as the fertilizer regime, time of harvest, and distillation techiques (9,22). For dill weed oil, the mature leaves contain more oil than the young growing stems at the vegetative stage. The stems and leaves are used in the steam distillation of dill weed oil. The seeds should be harvested for dill seed oil just as they start to ripen. The fruit will still be green in color. The dried fruits are crushed for dill seed oil. The dill oils are important commercially for pickles, condiments, meat products, chewing gum, candy, perfume, and soap (35). The laboratory steam distillation has revealed that oil content in the leaves rises progressively from umbel rosette stage through commencement of flowering up to mass flowering and declines thereafter (21).

Herbicide Application

The controlling of weeds in any crop is a serious problem. Weed control in herbs is important in that weeds can affect the color, aroma, and flavor of the dill and its oils. Ogg (37) and Wall (48) observed that dill was particularly sensitive to weed competition during the early portion of the growing season and found a 75-95% reduction in oil and seed yields when weeds were uncontrolled. To date the only registered herbicide for use on dill is Stoddard Solvent (49). Stoddard solvent, used as a postemergence herbicide, has become too expensive for normal usage; therefore, alternative herbicides need to be investigated (49).

Several studies have evaluated trifluralin and linuron (12,16,47). Trifluralin applied as a preplant incorporated at 0.56 or 1.12 kg/ha controlled lambsquarters and pigweed without injuring dill or reducing yields of the foliage, seed, or oil (12,16,47). Trifluralin did not control shepards-purse or tumble mustard. Injury and reduction of yields from the use of linuron was reported in a Washington study (37) and by other researchers (1,13,16,47,48). Ogg (37) observed that linuron applied as a post-emergence herbicide after the dill had at least five leaves or a height greater than 7.6 cm, did not severly injure dill, contrary to other published results (13,16,47,48). Ethalfluralin has been applied to dill as a preplant incorporate at 1.0 to 2.0 kg/ha and has provided effective weed control with little effect on crop yields (13,16,48).

Asian studies on herbicides need to be examined as to their effectiveness on dill, availability to farmers, and the cost for

possible use in the United States. Khosla et al. (31) observed that seedlings (50 days old) were susceptible to amiden and dalapon which caused abnormal growth and inhibited height. Seed formation also was affected at all concentrations of amiden treatments at bolting and flowering stages (31). Gawronski (17) applied gesagard (50% prometryne) at 2 to 3 kg/ha immediately after sowing without crop injury, with 80 to 90% weed control effectiveness. A preemergence application of of chloralhydrate was damaging to dill (32). Maas (32) recommended preemergence or soil fumigation to prevent direct comtamination of the plants.

CHAPTER III

MATERIALS AND METHODS

This research study was divided into 3 sections: a grower survey, commercial production studies, and a marketing survey. The intent of the project was to compile information about herb growers' businesses, to develop cultural information necessary for the commercial production of dill, and to survey wholesale markets available to the grower.

Herb Industry Survey

To provide some idea of the herb industry in the United States and the problems associated with the production and marketing of herbs, spices, and medicinal plants, a survey (Table 1) was mailed to randomly selected growers. The focus of the thirteen questions was to establish the current cultural techniques for dill, marketing information on herbs and spices, size and nature of herb businesses, and problems associated with the herb and spice industry.

Th surveys were mailed to 56 growers, grower/wholesaler, and grower/retailer located predominately in the northeastern United States. Conclusions were based on the number of total responses to each question.

Table 1. Herb Industry Survey

---

1. My firm ____ grows ____ wholesales _____ retails _____ other.

2. I grow: ____ culinary; ____ medincinal; ____ aromatic herbs.

3. Most of my herbs are grown for sale as:

   ____ potted plants; ____ fresh cut; ____ dried leaves;
   ____ seeds; ____ products with herbs.

4. Our herbs are grown: ____ in a greenhouse;
   ____ as a field crop; ____ year round.

5. I use a traditional organic fertilizer (circle yes or no) and/or inorganic fertilizer (circle yes or no).

6. My approximate fertilizer ratio is: (example 5-10-10)

7. Applications of the fertilizers are made: ____ weekly;
   _____ bi-monthly; ____ monthly; _____ yearly; ____ other.

8. The herbs are grown in _____ soil or _____
   _____ soilless mixes. (State mixture you are using.)

9. I currently have ____ acres of herbs in production.

10. Our five most profitable herbs are:

    1. _____ 2. _____
    3. _____ 4. _____
    5. _____

11. The following herbs should be studied and why?
    (example: Rosemary-good market.)

    _____
    _____

12. I feel the greatest problem for the herb industry is:

13. How much have you increased your herb production in the last 5-10 years?

Name of firm: (optional)

Comments:

Cultural Studies

The cultural studies were divided into three field experiments: Experiment 1 investigated plant density; Experiment 2 investigated fertilizer rates and plant density; and Experiment 3 investiggated the effectiveness of herbicides on weed supression. Seeds were obtained from Herbst Bros. (Brewster, N.Y.) for Experiment 1 and 3 and Richters (Ontario, Canada) for Experiment 2. In all field trials, plants were direct-seeded using a cone seeder Planet Junior set for a seeding depth of 0.64 cm.

Experiment 1. The plants were seeded on 26 May 1982 on plots of fine, sandy loam at the University of Massachusetts in Amherst. Seedling emergence occurred approximately 12 days after sowing, and were hand-thinned at row widths of 25, 50, 75 cm to plant spacing of 10, 20, 30 cm. Weeds were controlled using a preemergence application of paraquat at 0.23 kg/ha and hand-hoeing. An aphid infestation was controlled with one application of insecticidal soap (Safer's Soap) using a hand-held sprayer on 14 July.

Crop growth was monitored at weekly intervals beginning 34 days after emergence by measuring height of 6 plants and fresh weights and dry weights of 2 within each treatment. Yields were calculated on a land area and individual plant basis. Umbel size and number of axillary branches were determined at 13 weeks after seed emergence. Experiment 1 was planted in a randomized, complete block design and replicated three times.

Experiment 2. The plants in Experiment 2 were seeded at the University of Massachusetts research farm, South Deerfield of a Hadley

silt loam. Phosphorus and potassium were applied preplant as a mixed fertilizer to provide 30 kg P and 58 kg K per hectare. Nitrogen was applied as ammonium nitrate at the time of sowing at rates of 0, 60, and 120 kg N/ha. Seeds were on 13 June 1984 and emergence occured 5 days after sowing. Weeds were controlled using a preplant incorporated application of ethalfluralin at 1.25 kg/ha and by hand-hoeing. Treatments were hand-thinned 2 weeks after emergence at row widths of 15, 25, 50 cm to plant spacing of 10 and 20 cm.

Plant growth was monitored at 14-day intervals, beginning 37 days after emergence by measuring height, fresh weight, and dry weight of 3 plants within each treatment. Yields were calculated on a land area and individual basis. Size of the terminal umbel and number of axillary branches were measured at 10 weeks after seedling emergence. The experimental design was a split-split plot with the main plots being row width and plant spacing and subplots being nitrogen levels with three replications per treatment.

Experiment 3. Weed control trials were conducted at the University of Massachusetts campus plots in Amherst on a fine, sandy loam. Seeds were sown on 3 August 1982, and emergence occurred 8 days after sowing. Preplant incorporated and preemergence treatments of herbicides were applied on 3 August 1982, and post-emergence treatments of herbicides were applied on 3 September (Table 2). All post emergence treatments received a preplant incorporated treatment of trifluralin applied by a hand-held sprayer.

Herbicide treatments were evaluated for crop phtotoxicity and weed control 33 days after seed emergence. Weed control was assessed

visually based on the number of weeds present and was rated on a scale from 0 to 10 where 0=no control, 7=commercially acceptable, and 10=perfect weed controil. Weed populations included: redroot pigweed (Amaranthus retroflexus L.), lambsquarter (Chenopodium album L.) and purslane (Portulaca olerica L.). Crop injury was rated visually using a 0 to 10 rating scale where 0=complete kill, 6=injury with slight yield reduction, and 10=no injury. All of the dill vegetation was harvested from a 18.2 meter length of a row. Height, fresh weight, and dry weight of dill foliage without umbels were measured at harvest, 58 days after sowing. The experience was conducted as a randomized complete block design with three replications per treatment.

Marketing Survey

Marketing information and the problems associated with marketing of herbs and spiced were identified in a survey conducted by telehone. The survey utilized 4 questionnaires directed to wholesales of fresh herbs (Table 3), wholesalers of dried herbs (Table 4), supermarkets (Table 5), and growers (Table 6). The focus of the questonnaires was to establish current and potential marketing avenues, purchasing information, and product packaging specifications associated with each of the 4 groups.

Table 2. Herbicides used in Experiment 3.

Common Name	Trade Name	Chemical Name
bentazon	Basagran	basagran 3-(1-methylethyl)-(1H)-2,1,3-benzothiadiazin-4(3H)-one 2,2-dioxide
DCPA	Dacthal	dimethyl tetrachloroterephthlalate
diclofop	Hoelan	2-[4-(2,4-dichlorophenoxy)phenoxy] propanoic acid
ethalfluralin	Sonalan	N-ethyl-N-(2-methyl-2-propenyl)-2,6-dinitro-4-(trifluoromethyl)benzenamine
linuron	Lorox	N'-(3,4dichlorophenyl)-N-methoxy-N-methylurea
sethoxydim	Poast	2-[1-(ethoxyimino)butyl]-5-[2-(ethylthio) propyl]-3-hydroxy-2-cyclohexen-1-one
trifluralin	Treflan	2,6-dinitro-N,N-dipropyl-4-(trifluro-methyl)benzenamine

Table 3. WHOLESALERS MARKETING QUESTIONNAIRE
(FRESH)

Firm name:_____

Contact person:_____

1. Purchasing herbs from:
   _____ Mass. grower
   _____ regional grower
   _____ national grower
   _____ jobber
   _____ other

2. If purchasing herbs nationally, would you prefer to buy locally?

3. Selling to:(rank as to sales volume, 1=highest)
   _____ supermarkets
   _____ vegetable/fruit stores
   _____ food brokers
   _____ other

4. Into what market would you like to see sales expanded?

5. Are you buying herbs:
   _____ seasonally
   _____ year round

6. Do you buy regionally or nationally grown herbs when necessary?
   _____ seasonally
   _____ year round

7. Has the demand for herbs increased/decreased over the past 5 years? .
   years?

8. Projected sales:

9. Is the present supply meeting the demand?

10. Are there any herbs in short supply? (specify)

11. What herbs are you currently marketing:

_____ basil	_____ sage
_____ chives	_____ savory
_____ coriander	_____ spearmint
_____ dill	_____ tarragon
_____ oregano	_____ thyme
_____ parsley	_____ watercress
_____ rosemary	_____ other(s)

12. Do you have any packagine requirements: yes/no
   _____ weighted bunch
   _____ random wieght
   _____ bulk ie. bushel
   _____ size limitations ie:specific height limitations

13. Do you have any quality standards?

14. Would a herb marketing association be beneficial?

15. Current problems associated with marketing herbs:

Table 4. WHOLESALE MARKETING QUESTONNAIRE
(DRIED)

Firm name:_____

Contact person:_____

1. Are you purchasing dried herbs:
   _____ U.S. grown
   _____ imports

2. If imports, why:
   _____ price
   _____ greater availabiltiy
   _____ quality

3. Who are you purchasing from:
   _____ grower
   _____ jobber
   _____ wholesaler

4. Are growers under contract?

5. What quality controls are required by your company?

6. Do you have specific packing requirements?

7. Has the demand for herbs increased/decreased over the last 5 years?

8. Projected sales:

9. Is the present U.S. supply meeting the demand?

10. Are there any herbs in short supply (specify)?

11. Who would a grower contact if interested in growing sizable quantities of herbs?

12. How could a U.S. grower obtain a greater share of the dried market?

13. Would a marketing association be beneficial:

14. Current problems associated with marketing herbs:

Table 5. SUPERMARKETS MARKETING QUESTONNAIRE

Firm name:_____

Contact person:_____

1. Who are you purchasing fresh herbs from: (rank)
   - _____ Mass. grower
   - _____ regional grower
   - _____ national grower
   - _____ wholesaler
   - _____ other

2. If you are purchasing nationally, would you prefer to buy Mass. grown?

3. Availability of herbs:
   - _____ seasonally
     - _____ locally
     - _____ regionally
     - _____ nationally
   - _____ year round
     - _____ locally
     - _____ regionally
     - _____ nationally

4. Do you purchase:
   - _____ bulk
   - _____ pre-packaged

5. Unit description:
   - _____ bulk ie. bushel basket
   - _____ weighted bunch
   - _____ random weight
   - _____ size limitations ie: height of plant

6. Do you have any quality standards?

7. What herbs are currently buying:
   - _____ basil
   - _____ chives
   - _____ coriander
   - _____ dill
   - _____ oregano
   - _____ parsley
   - _____ rosemary
   - _____ sage
   - _____ savory
   - _____ spearmint
   - _____ tarragon
   - _____ thyme
   - _____ watercress
   - _____ other(s)

8. Are there any herbs in short supply?

9. Has the sale of herbs increased/decreased in the past 5 years?

10. Where do you feel the market is going?

11. Would a herb marketing association be beneficial?

12. Current problems associated with marketing herbs:

Table 6. GROWERS MARKETING QUESTIONNAIRE

Firm name:_____

Contact person:_____

1. Do you market herbs:
   _____ fresh
   _____ dried

2. How are you marketing the herbs you grow:(rank as to sales volume, 1=highest)?

   _____ supermarkets
   _____ wholesaler
   _____ jobber
   _____ retail
   _____ restaurants
   _____ farm stands
   _____ other

3. Are you growing:
   _____ seasonally
   _____ year round

4. Are you selling:
   _____ bulk
   _____ pre-packaged

5. Would there be a market for year round, locally grown herbs?

6. Unit description:
   _____ bulk ie. bushel basket
   _____ weighted bunch
   _____ random weight
   _____ size limitations ie: specific height requirements

7. Who has established the specific pre-packaged requirements?

8. Are there any quality standards you are required to follow?

9. What herbs are you growing:

   _____ basil
   _____ chives
   _____ coriander
   _____ dill
   _____ oregano
   _____ parsley
   _____ rosemary
   _____ sage
   _____ savory
   _____ spearmint
   _____ tarragon
   _____ thyme
   _____ watercress
   _____ other

10. Have you or are you planning to increasing production?

11. How long have you been growing herbs?

12. Do you feel the demand for herbs will increase or decrease? Why?

13. Is the market approaching saturation?

14. Are you interested in selling bulk dried herbs?

15. What market would you like to expand into and what is the reason holding you back?

16. Current problems associated with marketing herbs:

CHAPTER IV

RESULTS

Herb Industry Survey

Thirty-six growers (64%) answered the survey. The collective responses to a survey of the growers suggested an interest in their learning more about the production of herbs and the need to identify and solve problems. Lack of knowledge was the main concern of 49% of those responding. Other concerns included: lack of cultural and pest information, inability to identify botanically and obtain different species and forms of a particular herb; lack of understanding of factors that influence the quality of herbs, and problems associated with contradictory and misinformation.

Approximately half of the respondents (52%) had between one and five acres of herbs in production whereas another third of the respondents (36%) had less than one acre. A small proportion of the respondents (4%) were growing herbs on more than ten acres. The survey did not distinguish in the acreage reports whether growers included ornamental or specialty crops or greenhouse production.

Herbs were reported to be grown in the field by 77% of the respondents, grown in the greenhouse by 74%, and in both by 38%.

Interest was indicated in growing herbs off season in the greenhouse for the fresh market, but lack of information on suitable production systems and economic costs inhibit the expansion of this area. Sixty percent of the respondents were growing herbs seasonally rather than year-round.

Eighty-seven percent of the businesses were growing a combination of culinary, aromatic, and medicinal herbs. Thirty different herbs were listed as the most profitable by the growers. The five most commonly cited were rosemary (54%), french tarragon (52%), oregano (38%), sweet basil (34%), and lavender (15%). The majority of the respondents (81%) sell herbs as potted plants. Growers indicated a preference for organic fertilizers (89% responses) versus inorganic fertilizers (74%). The more popular fertilizers were bone meal and fish emulsion for organic and 5-10-10 and 20-20-20 for inorganic fertilizer. Most growers indicated that the type, rate, and time of fertilizer applications were based on habit or personal preference rather than on scientific experimentation. Sixty-eight percent were growing potted herbs in greenhouse soil mix, and thirty-two percent were using a soilless mix.

Cultural Studies

Experiment 1. The influence of plant density on the growth and development of dill, Year 1. The highest foliar yield was produced at the closest plant spacing of 10 cm in rows and the narrowest row width of 25 cm (Figure 1). Row width and plant spacing treatments were converted to the number of plants per square meter or plant density (Table

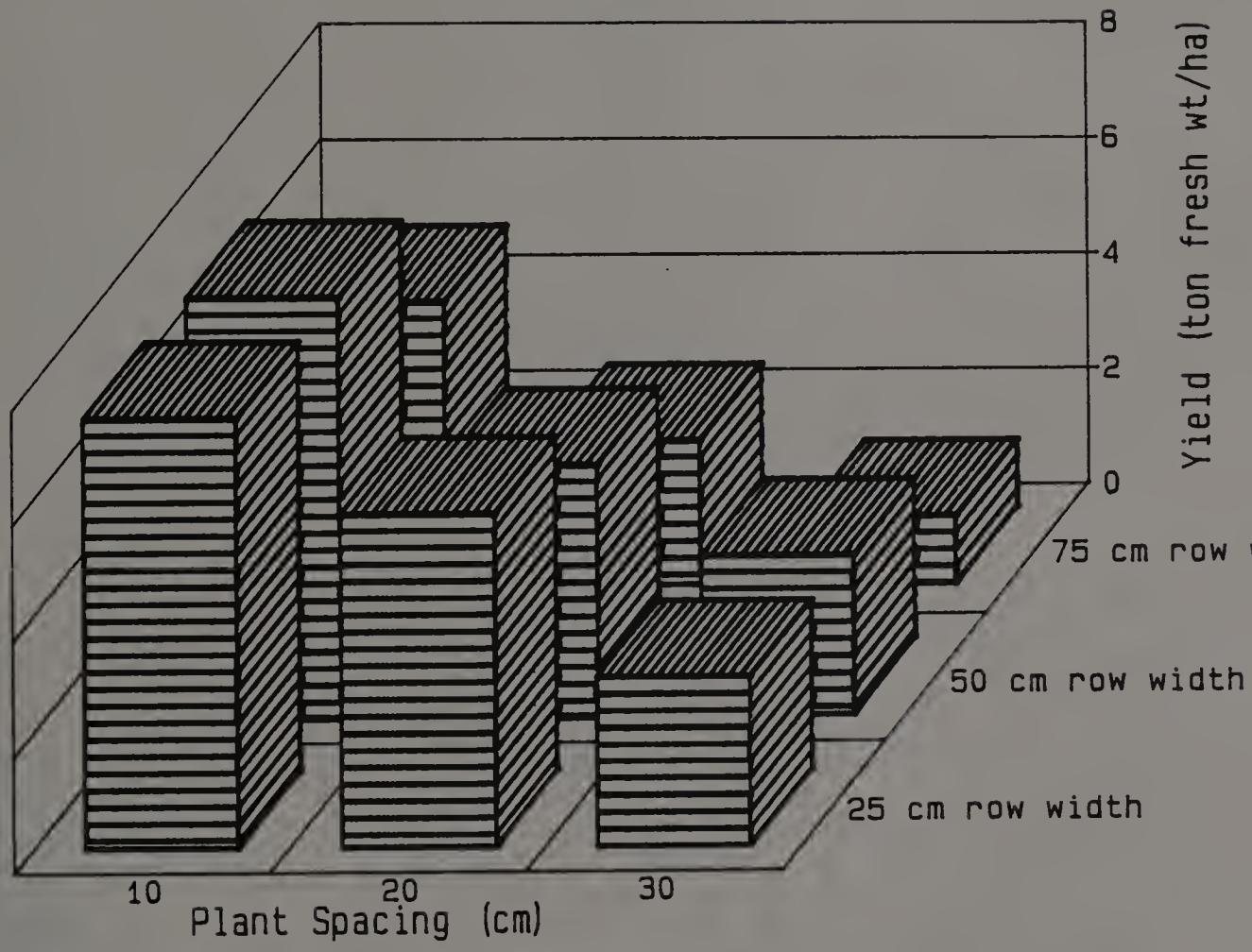
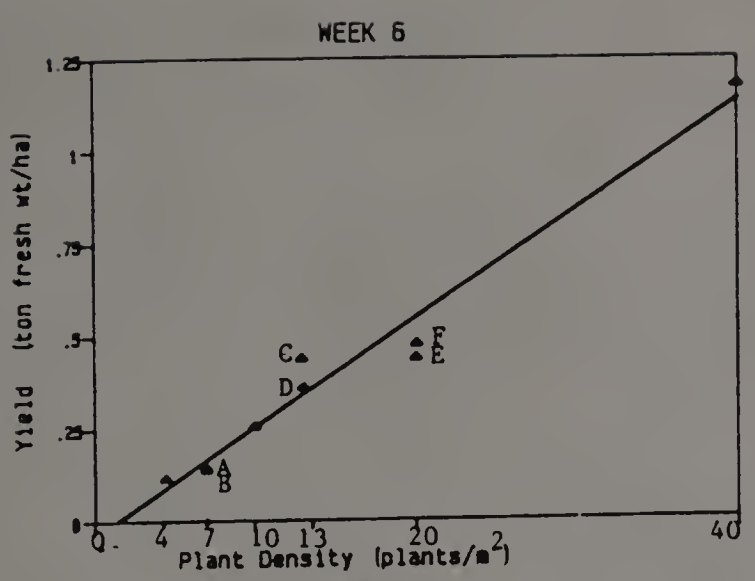
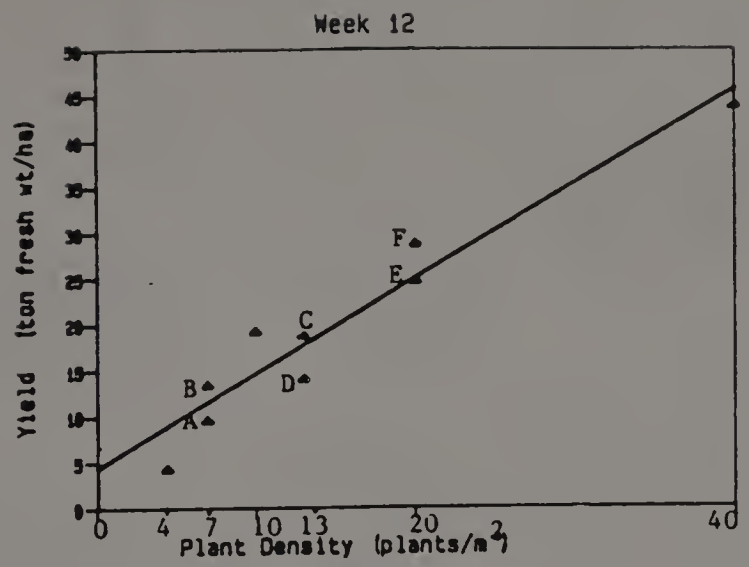


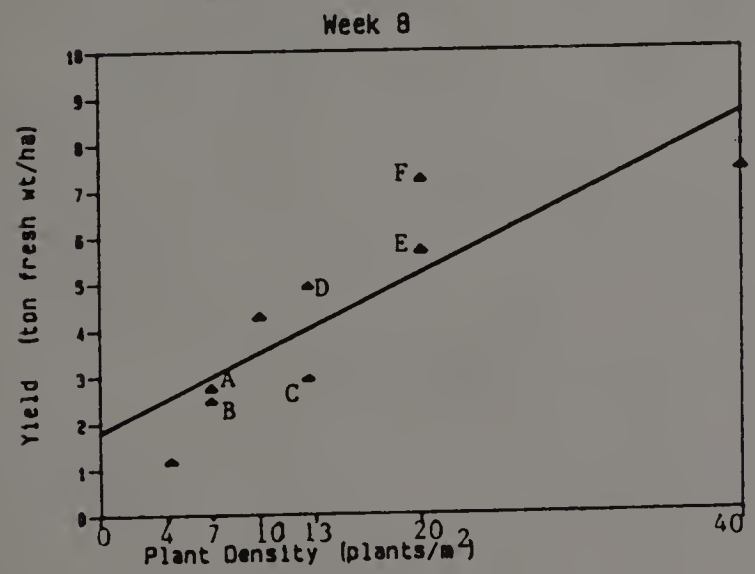
Figure 1. Effect of Row Width and Plant Spacing on Dill Yield (Exp. 1).

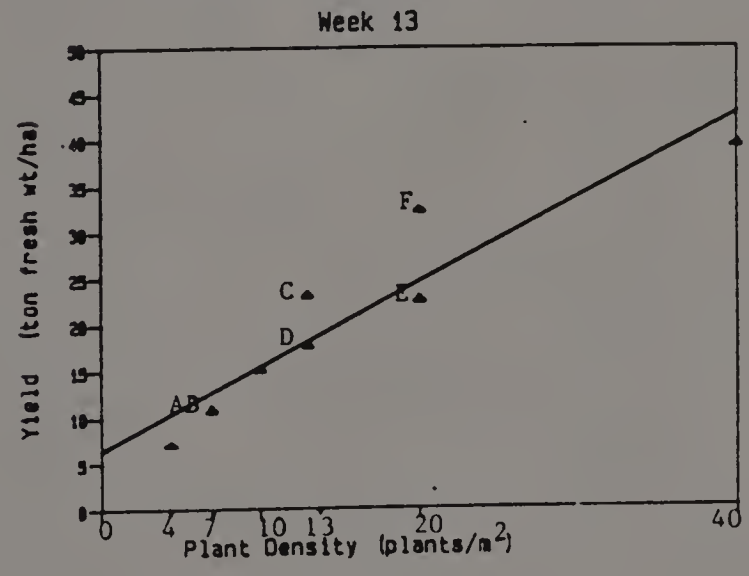
Table 7: Conversion of row width and plant spacing to plant density.

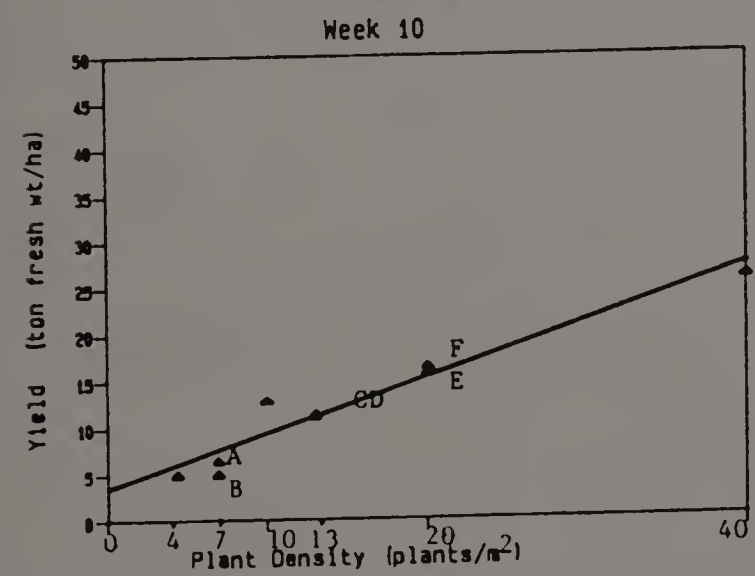
Row Width	Plant Spacing	Plant Density
cm	cm	plants/m2
Experiment 1		
25	10	40
	20	20
	30	13
50	10	20
	20	10
	30	7
75	10	13
	20	7
	30	4
Experiment 2		
15	10	68
	20	33
25	10	40
	20	20
50	10	20
	20	10











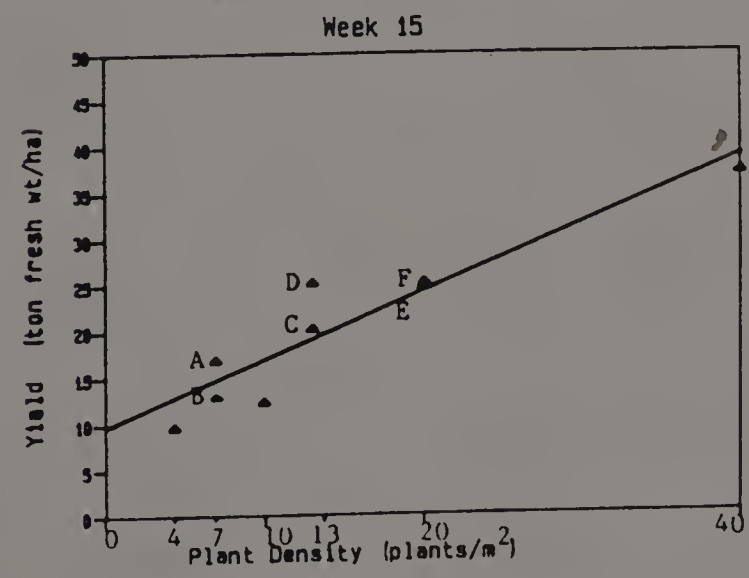


Figure 2. Effect of Plant Density on Dill Yield.
A = 50 row width x 30 plant spacing
B = 75 row width x 20 plant spacing
C = 25 row width x 30 plant spacing
D = 75 row width x 10 plant spacing
E = 25 row width x 20 plant spacing
F = 50 row width x 10 plant spacing

7). Foliar yields increased linearly at all harvest intervals as the number of plants per unit area increased (Figure 2).

Fresh weight of dill weed (foliage without umbels) increased as the plant matured until 12 weeks after germination with 40 plants/m^2 and at 13 weeks with 20 plants/m^2 after which the fresh weight declined (Figure 3). At 13 plants/m^2, fresh weight increased throughout the season. Height was not affected by plant density.

Plant density had no significant effect on the number of axillary branches or on the diameter of the terminal umbel (Table 21). On each dill plant there were 12 to 13 axillary branches. The diameter of the terminal umbel ranged from 14 to 16 cm.

Experiment 2. The effect of nitrogen and plant density on growth and development of dill, Year 2. As the row width was decreased from 50 to 15 cm and plant spacing was decreased from 20 to 10 cm, yields increased (Figure 4). The highest foliar yield was attained at the closest plant spacing of 10 cm and the narrowest row width of 15 cm.

Foliar yields increased significantly within plant density (Fig. 5,6,7). A quadratic relationship was noted between yield and plant density without nitrogen, and there was a linear increase if fertilizer was added. Maximum fresh weight occurred with a plant density of 68 plants/m^2 with 120 kg/ha of nitrogen for weeks 8 and 10 (Fig. 6,7). At week 6, the highest foliar yield was attained at 68 plants/m^2 with 60 kg/ha nitrogen (Fig. 5).

Fresh foliar yields increased as the plant density increased and the fertilizer rate increased. The highest yield of 83 metric ton fresh wt/ha was attained with a planting density of 68 with 120 kg/ha

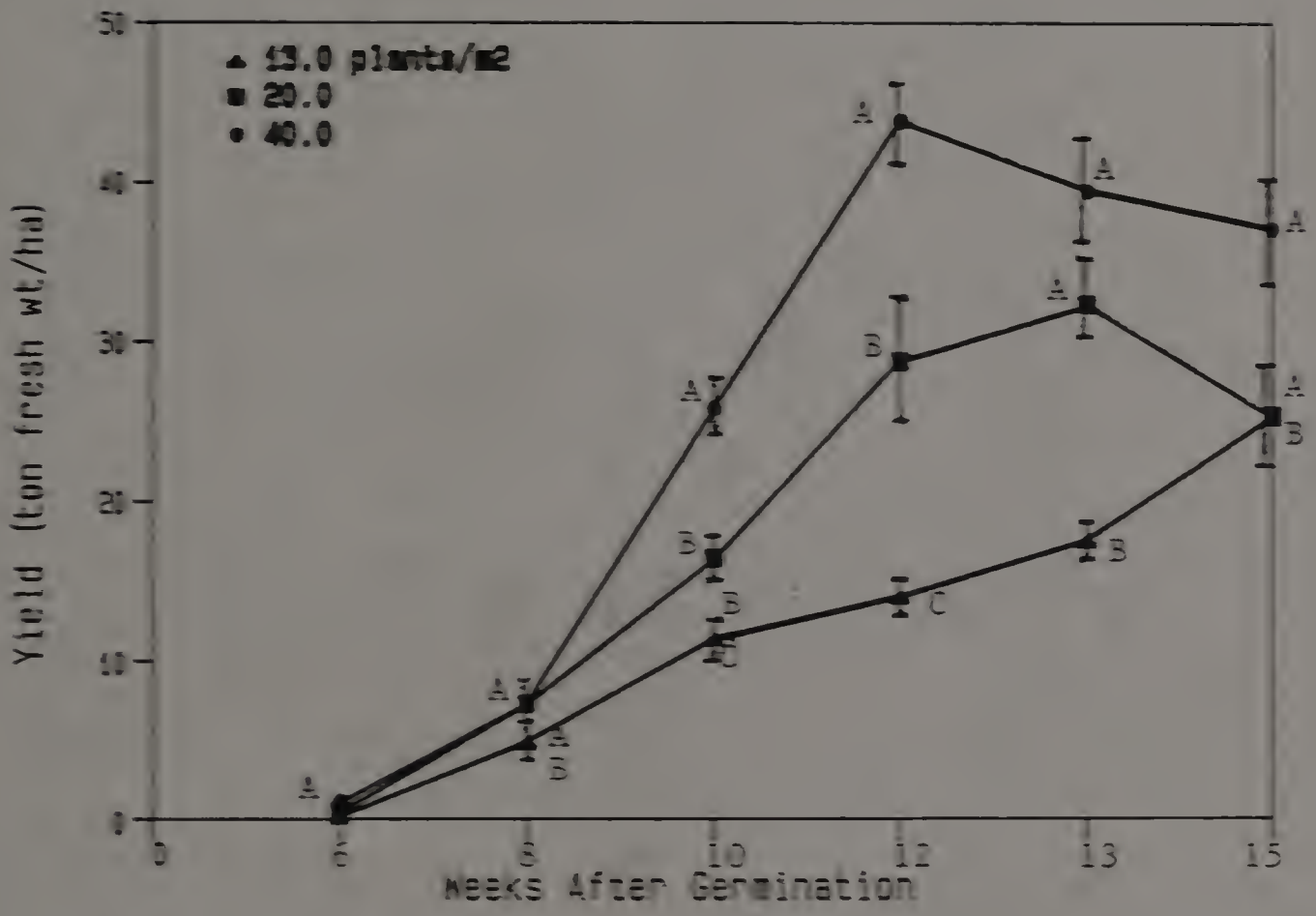


Figure 3. Effect of Plant Density on Dill Development. Duncan's Test .05 Level, Among Plant Densities

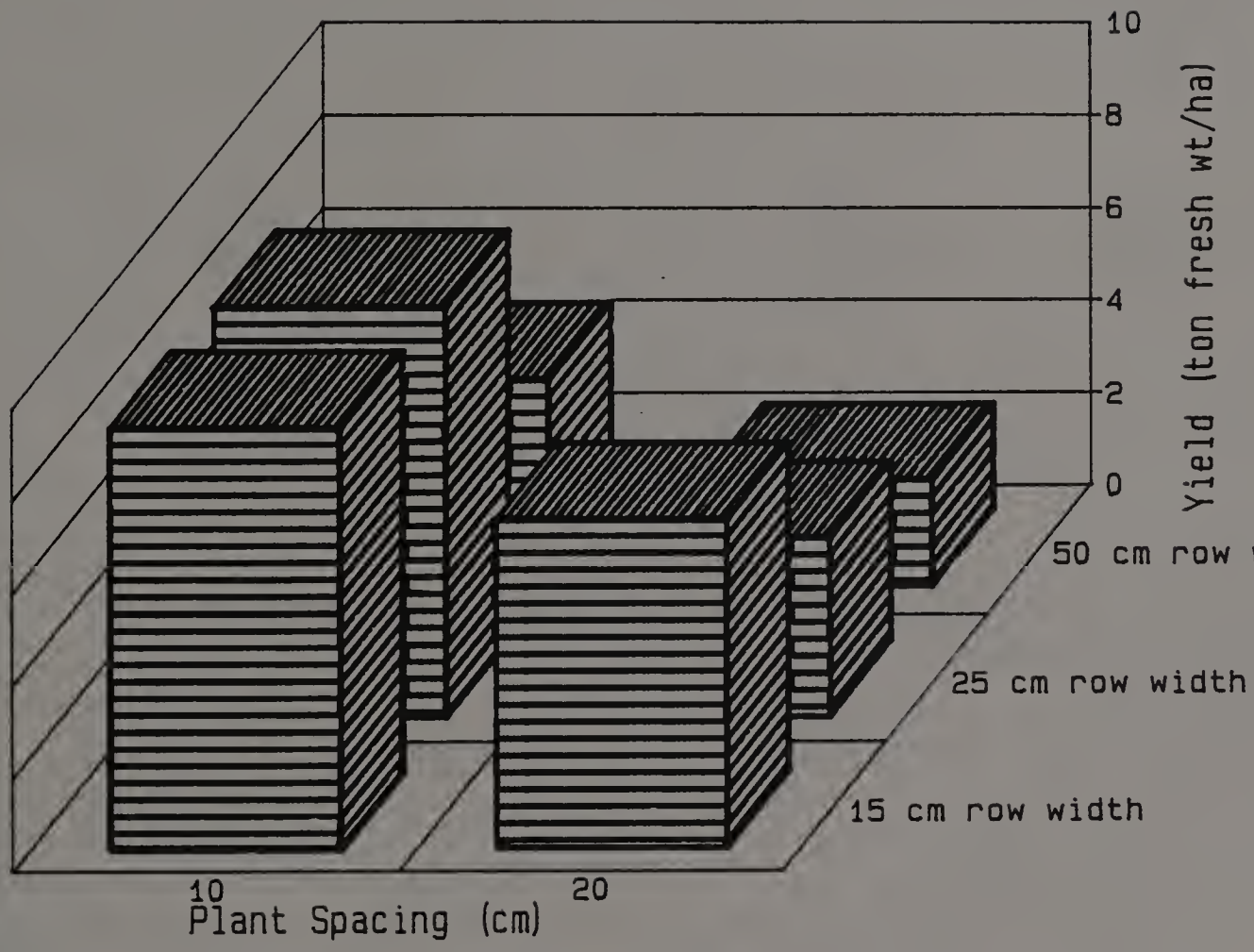


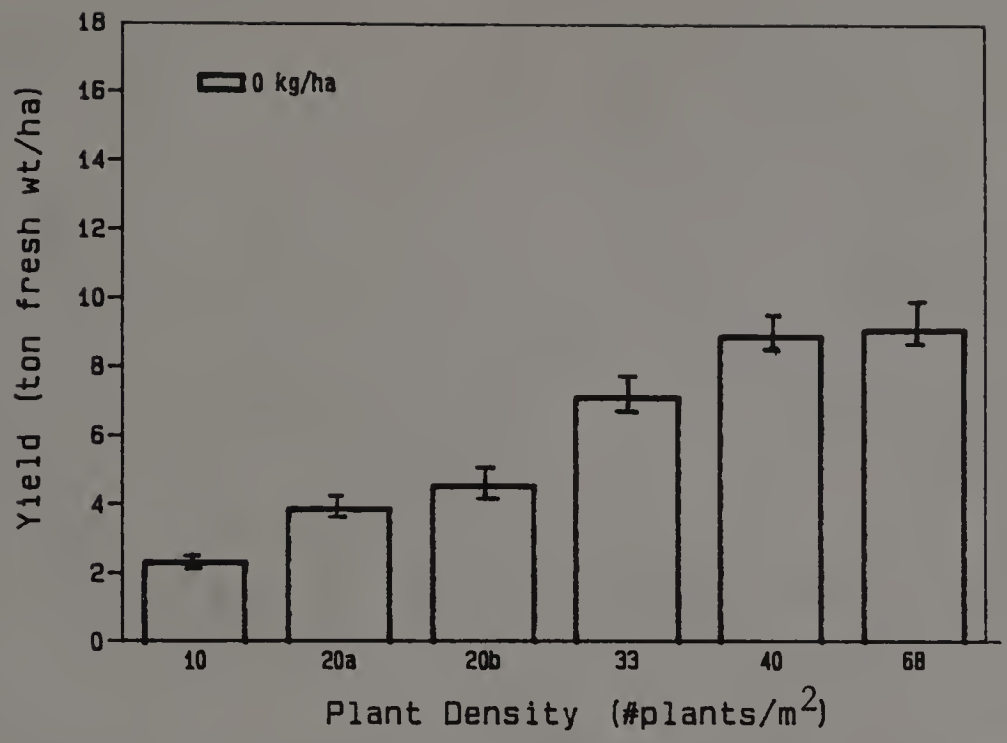
Figure 4. Effect of Row Width and Plant Spacing on Dill Yield (Exp. 2).

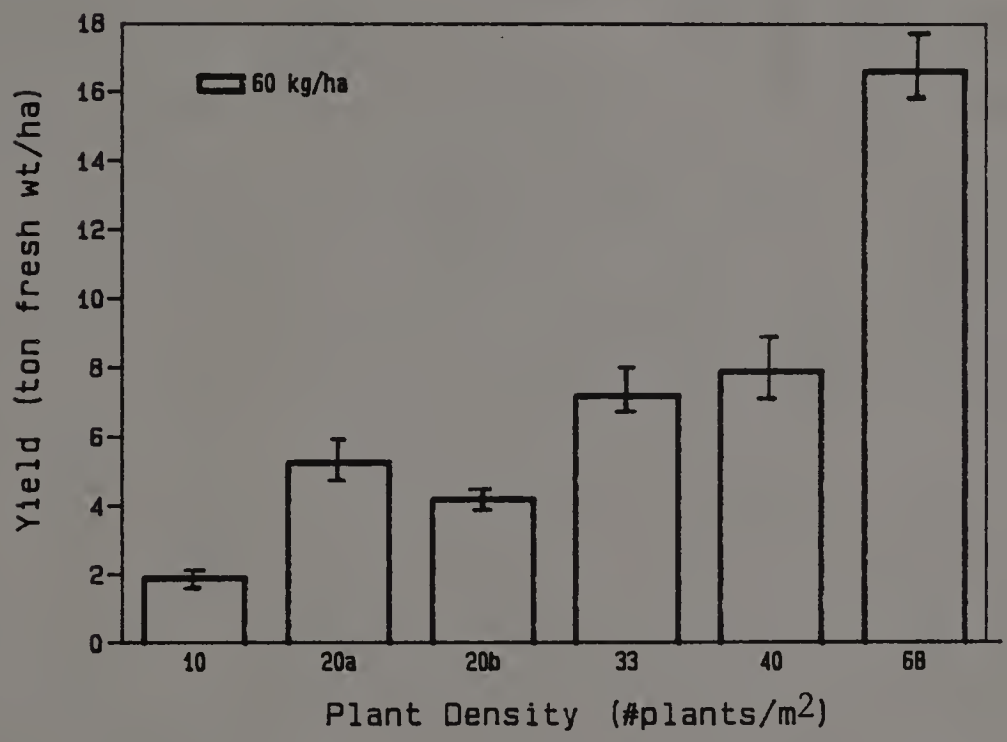
Figure 5. Effect of Nitrogen and Plant Density on Dill Yield at Week 6 (Exp 2). (a= 25 cm row width x 20 cm plant spacing, b= 50 cm row width x 10 cm plant spacing) Bars indicate SE values; data points without bars have SE values within the data point.

0 Nitrogen R^2= 0.588
$Y= -1.572+0.371d+0.003d^2$

60 Nitrogen R^2= 0.618
$Y= -0.628+0.245d$

120 Nitrogen R^2= 0.619
$Y= -0.244+0.209d$


0 kg/ha
Yield (ton fresh wt/ha)
0
2
4
6
8
10
12
14
16
18
10
20a
20b
33
40
68
Plant Density (#plants/m2)


60 kg/ha
Yield (ton fresh wt/ha)
0
2
4
6
8
10
12
14
16
18
10
20a
20b
33
40
68
Plant Density (#plants/m2)

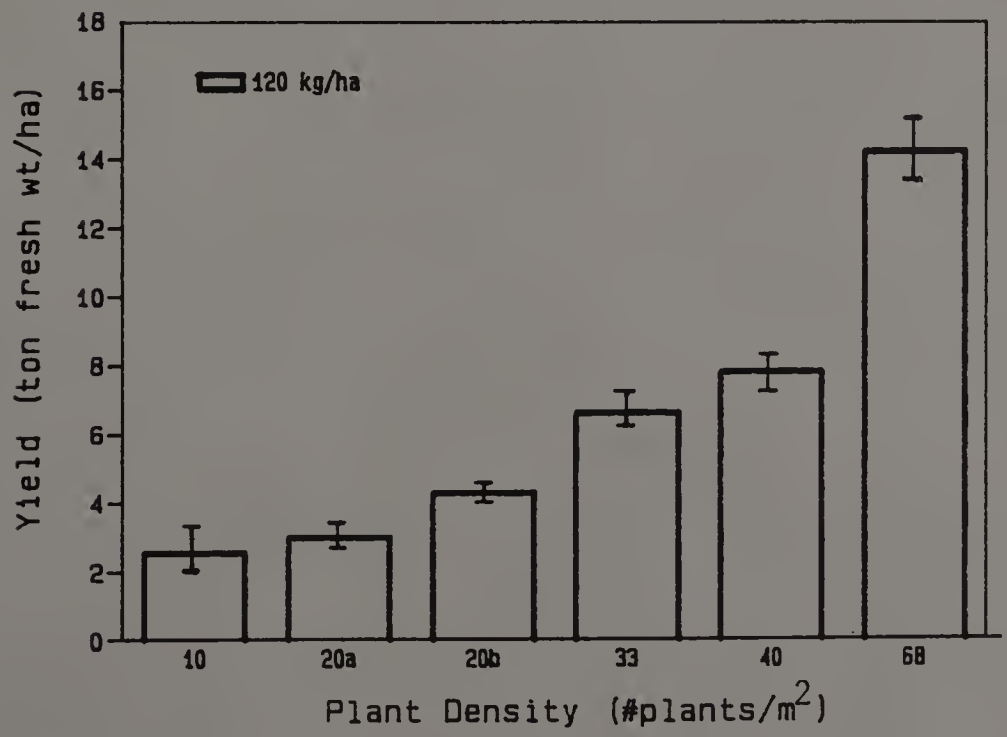
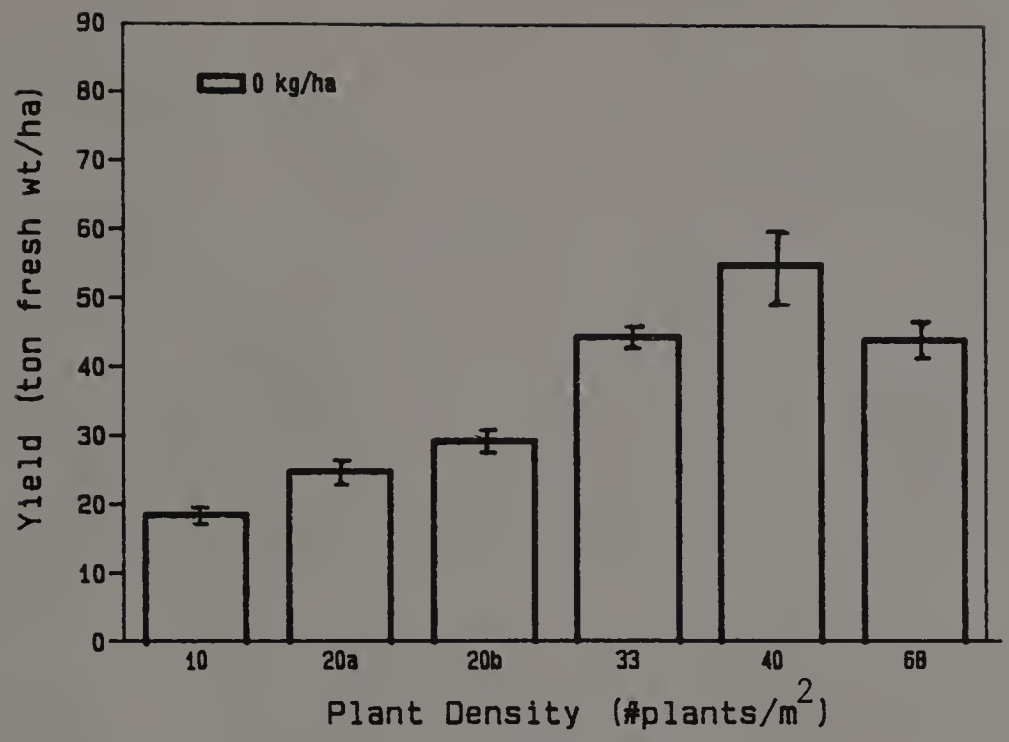

120 kg/ha
Yield (ton fresh wt/ha)
0
2
4
6
8
10
12
14
16
18
10
20a
20b
33
40
68
Plant Density (#plants/m2)

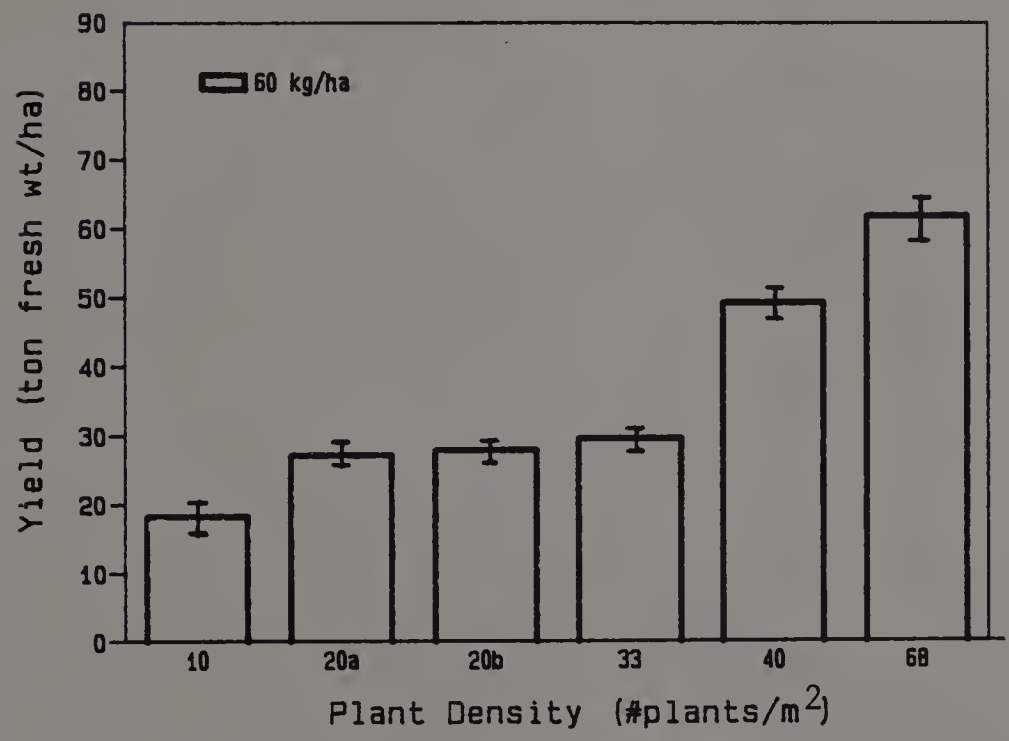
Figure 6. Effect of Nitrogen and Plant Density on Dill Yield at Week 8 (Exp 2). (a= 25 cm row width x 20 cm plant spacing, b= 50 cm row width x 10 cm plant spacing) Bars indicate SE values; data points without bars have SE values within the data point.

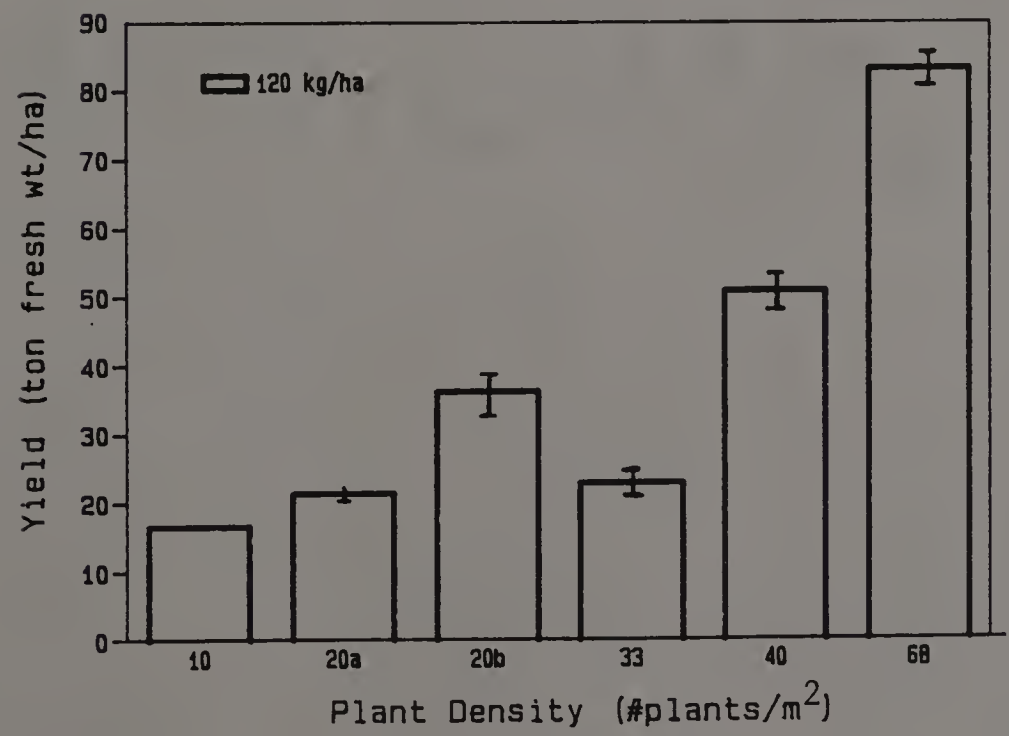
0 Nitrogen R^2= 0.351
$Y= -6.297+2.356d+0.023d^2$

60 Nitrogen R^2= 0.620
$Y= 11.442+0.765d$

120 Nitrogen R^2= 0.724
$Y= 2.582+1.134d$


0 kg/ha
Yield (ton fresh wt/ha)
0
10
20
30
40
50
60
70
80
90
10
20a
20b
33
40
68
Plant Density (#plants/m2)


60 kg/ha
Yield (ton fresh wt/ha)
0
10
20
30
40
50
60
70
80
90
10
20a
20b
33
40
68
Plant Density (#plants/m2)


120 kg/ha
Yield (ton fresh wt/ha)
0
10
20
30
40
50
60
70
80
90
10
20a
20b
33
40
68
Plant Density (#plants/m2)

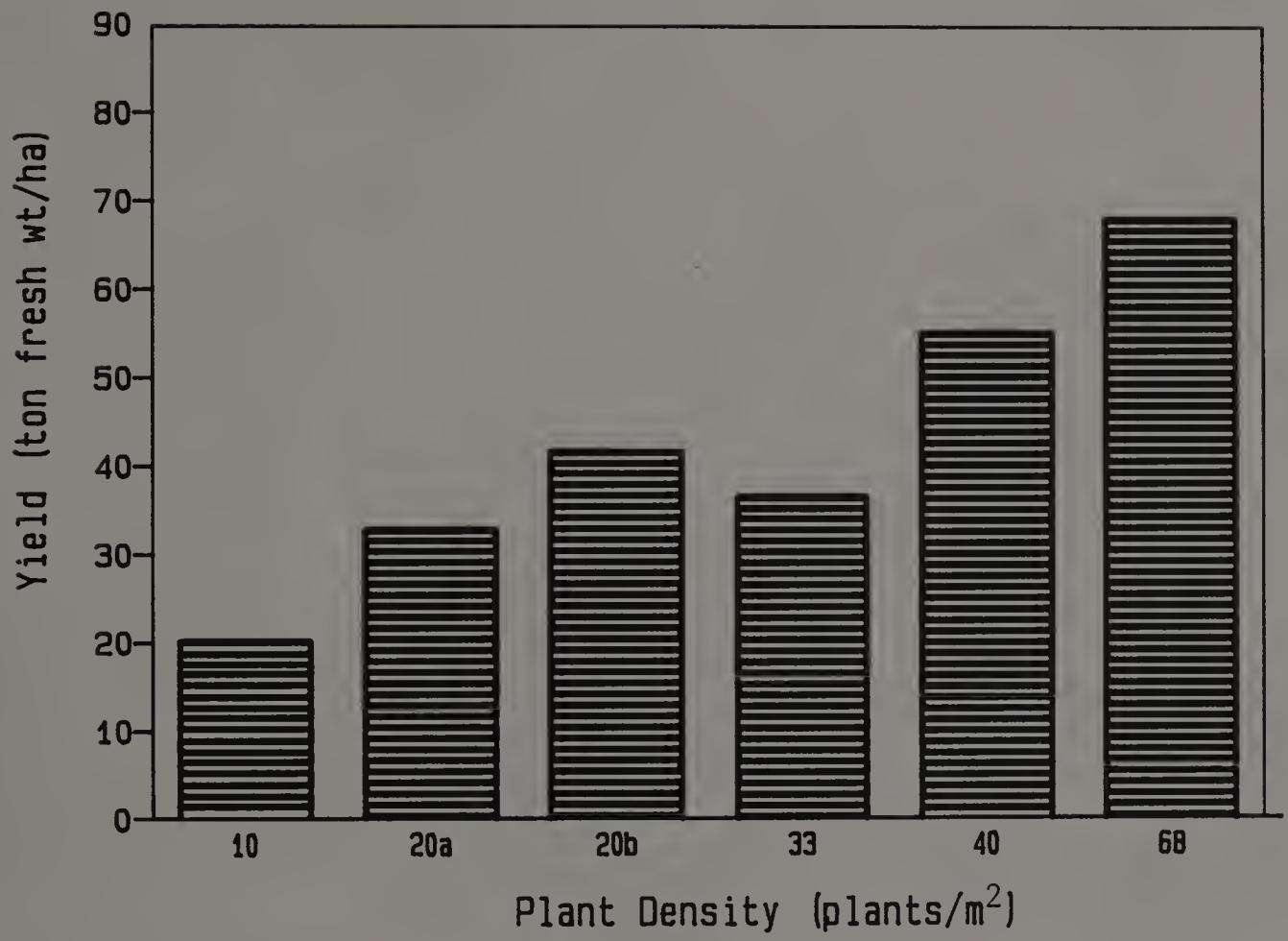


Figure 7. Effect of Plant Density on Dill Yield at Week 10 (Exp. 2). (a = 25 cm row width x 20 cm plant spacing, b = 50 cm row width x 10 cm plant spacing)

nitrogen (Table 8). This yield is a threefold increase when compared to 27 metric ton fresh wt/ha at a common commercial planting rate of 20 plants/m^2 (25 cm row width x 20 cm plant spacing) with 60 kg/ha nitrogen (Table 8). The interaction between plant density and fertilizer treatment was significant at the 0.05 level for fresh foliar yield (Table 24).

At a plant density of 68 plants/m^2, nitrogen influenced the yields in weeks 8 and 10 (Figure 8). At 6 weeks, nitrogen fertilization appeared to have little effect on foliar yield. There was a pronounced linear effect across the nitrogen levels at weeks 8 and 10, the higher the nitrogen level the greater the yields.

The effect of plant density and nitrogen treatments on the per plant fresh weight of dill are indicated in Figure 9. The highest fresh weight per plant was 185 grams attained at 10 plants/m^2 with no nitrogen. The fresh weight per plant increased as the number of plants per unit area decreased.

Height was affected by plant density only at 6 weeks, the higher the plant density the taller the plants grew. Fertilization had no significant effect on height at any measurement period (Table 23-25). However there was a significant plant density x fertilizer interaction at week 8 (Table 9). The lowest plant density of 10 plants/m^2, the average height of 116 cm was significantly greater than that of other treatments that averaged 102 to 109 cm. (Table 9). Neither plant density nor fertilization had any effect on plant height at week 10.

Table 8: Effect of plant density and nitrogen on fresh yield (metric ton/ha) of dill at 8 weeks after germinations. (Exp. 2)

Plant Density (plants/m^2)	Fertilizer Levels (kg/ha) 0	60	120
10	18.51	18.30	16.62
20a	24.88	27.22	21.48
20b	29.38	28.09	36.43
33	44.56	29.78	23.04
40	55.10	49.42	51.08
68	44.26	61.95	83.40
LSD 0.05			16.02

a= 25 cm row width x 20 cm plant spacing, (common commercial planting rate)
b= 50 cm row width x 10 cm plant spacing

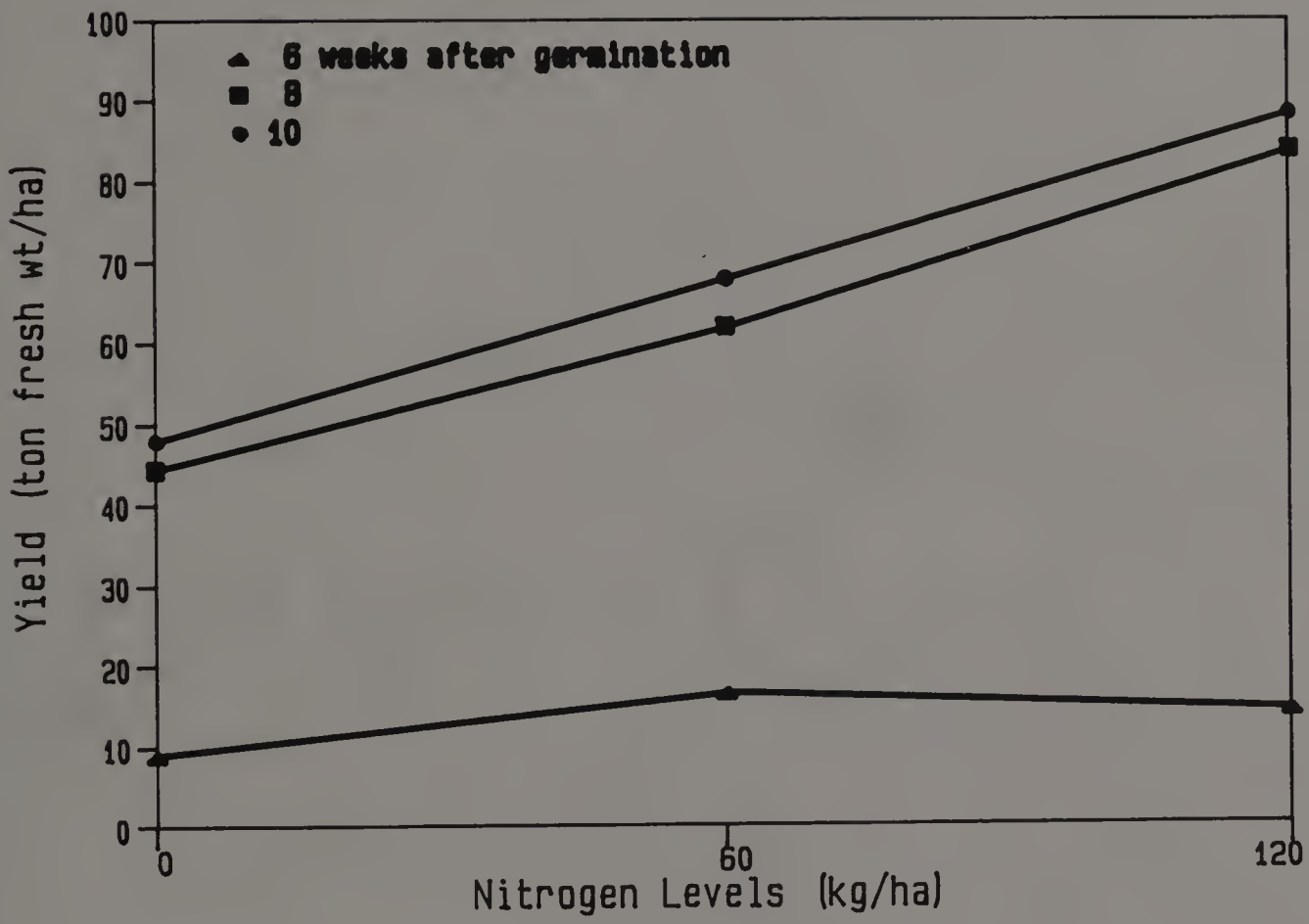
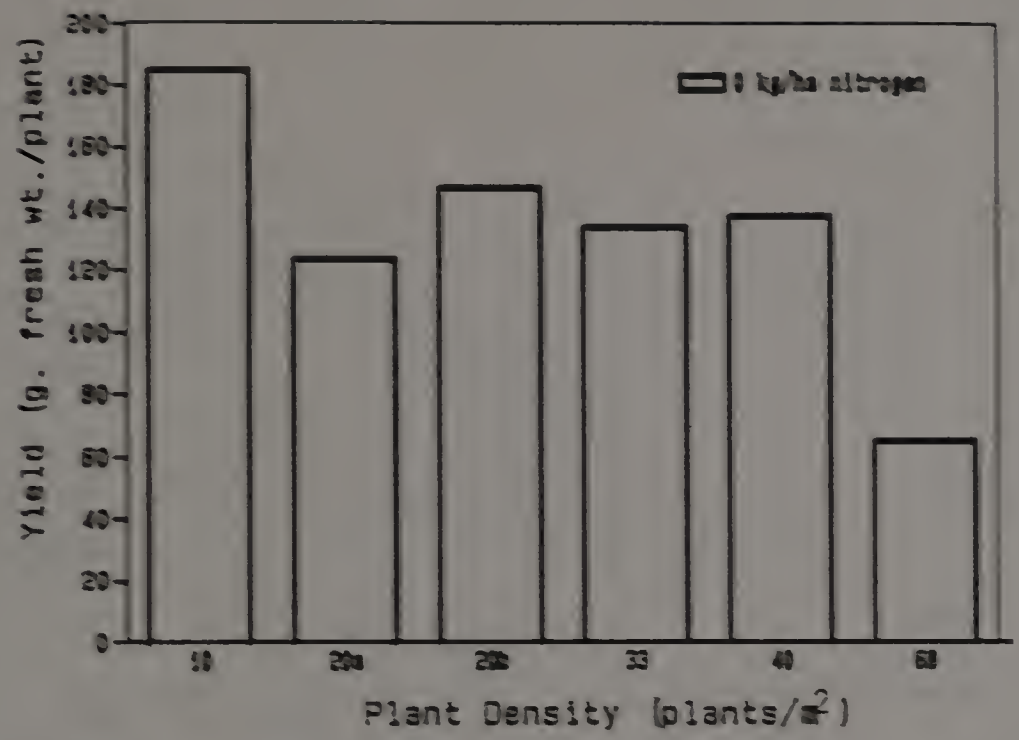
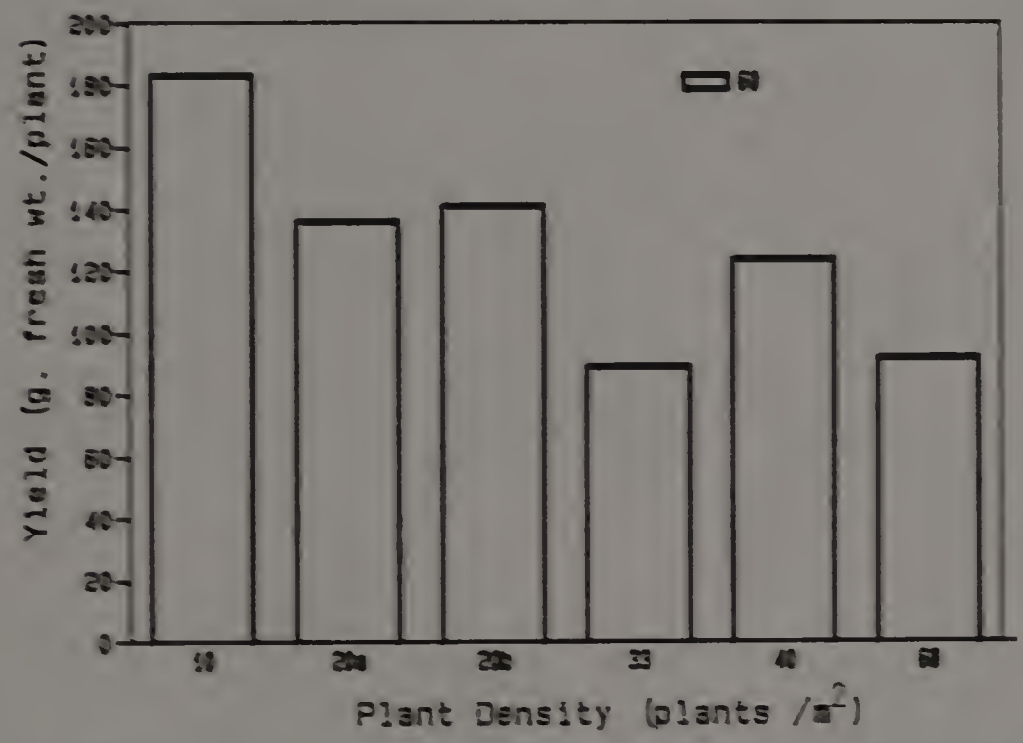


Figure 8. Effect of Nitrogen on Development of Dill at 68 plants/m^2.

Figure 9. Effect of Plant Density and Nitrogen on Per Plant Fresh Weight of Dill at Week 8 (Exp 2). (a= 24 cm row width x 20 cm plant spacing, b= 50 cm row width x 10 cm plant spacing)


Yield (g. fresh wt./plant)
0
20
40
60
80
100
120
140
160
180
200
Plant Density (plants/m²)


Yield (g. fresh wt./plant)
0
20
40
60
80
100
120
140
160
180
200
Plant Density (plants /m²)

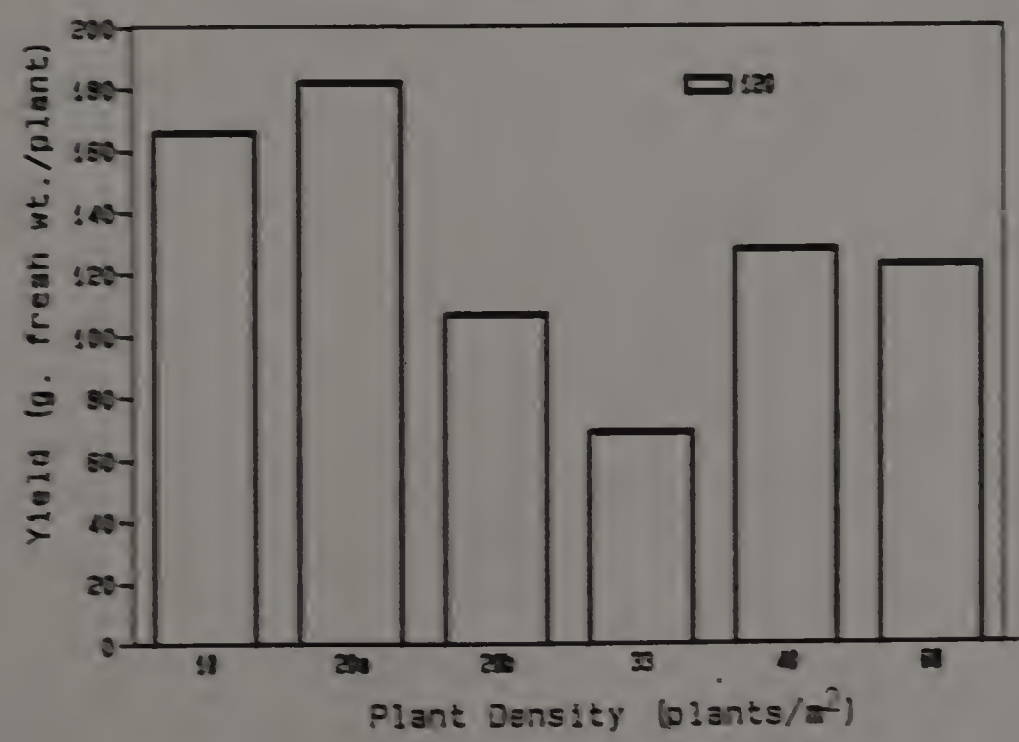

Yield (g. fresh wt./plant)
0
20
40
60
80
100
120
140
160
180
200
Plant Density (plants/m²)

Table 9: Effect of plant density and nitrogen on height (cm) of dill at 8 weeks after germination.

Plant Density (plants/m^2)	Fertilizer Levels (kg/ha)		
	0	60	120
10	121	116	112
20a	109	108	107
20b	107	106	105
33	105	105	104
40	104	104	99
68	106	114	106
LSD 0.05			8

a= 25 cm row width x 20 cm plant spacing (common commercial planting rate)
b= 50 cm row width x 10 cm plant spacing

Neither nitrogen fertilization nor plant density had any significant effect on the number of axillary branches (Table 21). The diameter of the terminal umbel was affected by planting density but was not by nitrogen levels (Table 26). The diameter of the terminal umbel was larger the less dense the plant population (Figure 10). The largest umbel was attained with a plant density of 20 plants/m^2 (50 cm row width x 10 cm plant spacing).

Experiment 3. The effectiveness of herbicides on weed control and their influence on the development of dill. Greatest yield of fresh cut and dried dill occurred if ethalfluralin was applied pre plant incorporated or preemergence at a rate of 1.25 kg/ha (Table 10). The preplant incorporated ethalfluralin treatment provided better control of redroot pigweed and lambsquarter than purslane, however, ethalfluralin applied preemergence provided better control of purslane than redroot pigweed and lambsquarter (Table 11). The fresh foliar yields of dill with the treatments of DCPA, trifluralin with diclofop, and trifluralin with sethoxydim equaled the yields of the ethalfluralin treatments. Weed control by DCPA was below the commercially acceptable level. Trifluralin with sethoxydim provided total control of purslane, commercially acceptable control of redroot pigweed, and unacceptable control of lambsquarter. Trifluralin with diclofop provided commercially acceptable weed control.

Treatments trifluralin with bentazon, trifluralin with linuron, and linuron resulted in yields significantly lower than those observed with ethalfluralin, DCPA, and trifluralin with diclofop (Table 10). Plant height responded in a similar fashion to the fresh weight

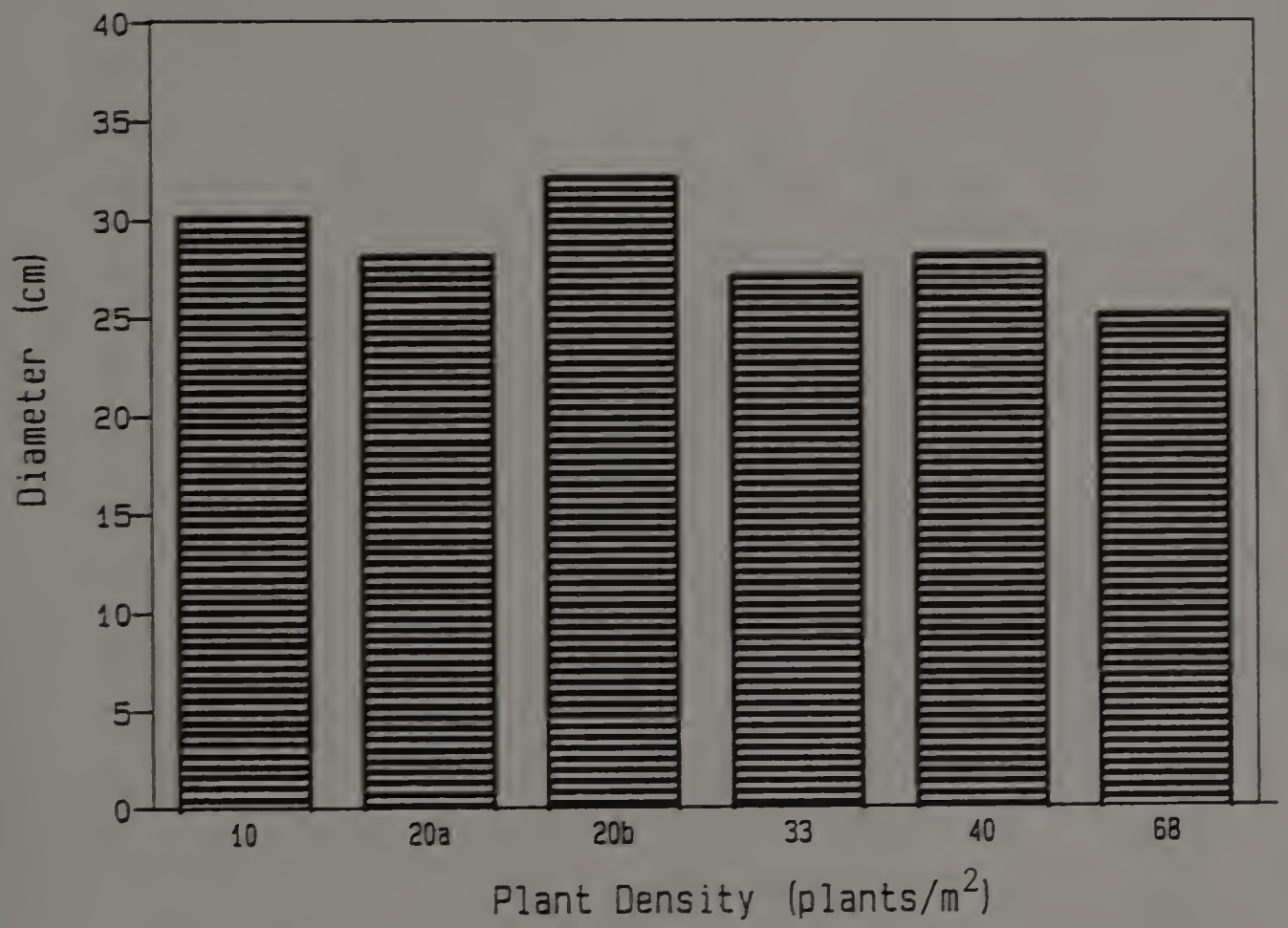


Figure 10. Effect of Plant Density on the Diameter of the Terminal Umbel (Exp. 2). (a = 25 cm row width x 20 cm plant spacing, b = 50 cm row width x 10 cm plant spcaing)

Table 10: Effect of pre-plant incorporated (PPI), preemergence (PRE) and post emergence (POST) herbicides on plant height and fresh weight in dill.

Treatment	Rate	Method	Growth	
			Height	Fresh Wt.
	(kg/ha)		(cm)	(metric ton/ha)
ethalfluralin	1.25	PPI	15 ab	1.249 a
ethalfluralin	1.25	Pre	18 a	1.280 a
DCPA	8.9	Pre	14 ab	1.164 ab
trifluralin with diclofop	1.12 1.12	PPI Post	17 a	1.174 ab
trifluralin with sethoxydim	1.22 0.22	PPI Post	16 ab	0.995 ab
trifluralin with sethoxydim with bentazon	1.12 0.2 0.8	PPI Post Post	10 bc	0.530 cd
linuron	0.56	Pre	8 c	0.501 cd
linuron	0.56	Post	8 c	0.274 d
trifluralin plus linuron	1.12 0.56	PPI Post	10 bc	0.748 bc
Uncultivated			18 a	0.446 cd
Cultivated			13 ab	0.950 ab

Mean separation by Duncan's Multiple Range Test, 0.05. Means followed by the same letter are not significantly different.

Table 11: Effect of pre plant incorporated (PPI), preemergence(PRE), and post emergence (POST) application of herbicides on weed control and phytotoxicity in dill.

Treatment			Response				
Herbicide	Rate (kg/ha)	Method	Weed[x] Control	Crop[y] Injury	Weed Count[z] (plants/m^2)		
					RRP	LQ	PUR
ethalfluralin	1.25	PPI	8.0	8.8	7	14	18
ethalfluralin	1.25	Pre	6.8	9.1	22	32	0
DCPA	8.9	Pre	6.8	9.3	14	7	0
trifluralin plus	1.12	PPI	7.3	9.5	11	25	25
diclofop	1.12	Post	7.0	9.5			
trifluralin plus	1.12	PPI	7.1	9.3	14	29	0
sethoxydim	0.22	Post	5.6	9.5			
trifluralin plus	1.12	Post	6.0	6.0			
sethoxydim plus	0.2	Post	6.0	6.0	18	39	7
bentazon	0.8	Post					
linuron	0.56	Pre	9.2	5.9	0	7	0
linruon	0.56	Post	1.0	10.0	32	61	36
trifluralin plus	1.12	PPI	8.3	9.3	7	14	7
linuron	0.56	Post	9.5	8.6			
Uncultivated				10.0	39	57	22
Cultivated			10.0	10.0	0	0	0

x Weed control: 0=no control; 7=commercially acceptable; 10=complete control.

y Crop injury: 0=complete kill; 6=injury with slight yield restriction; 10=no injury.

z Weed count: RRP=redroot pigweed; LQ=lambsquarter; PUR=purslane.

results. Linuron applied as a post treatment resulted in no crop injury yet maintained the highest weed population. Preemergence linuron treatments resulted in reduced fresh weight yields and stunted height of the dill relative to the post emergence treatment of bentazon with sethoxydim was phytotoxic and produced burned, unmarketable foliage (Table 11). Sethoxydim alone was not phytotoxic. Linuron applied as a post emergence provided minimal weed control of the three species counted; however if applied preemergence it provided total control of redroot pigweed and purslane.

Marketing Survey

Growers Questonnaire. Four our of the seven growers surveyed have been growing herbs from 5 to 7 years. Five of growers grew for the fresh market, with one grower marketing fresh and dried herbs. Most were selling to local wholesalers; the next marketing avenue being restaurants and supermarkets, health food stores, and gourmet shops. Farmers markets were the last marketing channel chosen.

All but one growers has increased or will increase their production. One grower marketing dried herbs had doubled his production of herbs since 1983 and planned an increase of another 25%. Due to personal reasons one grower was decreasing production. Five agreed that the demand for herbs would increase due to trade restrictions, health consciousness, consumer interest in ethnic cooking, and with more chefs knowledgeable in the use of herbs. All growers surveyed were marketing 10 or more varieties of herbs.

The number one quality standard was visually rating herbal foliage for spots, insect damage, flower buds, turgid stems, and uniform stem length. Due to competition in the area, one grower marketed herbs picked and delivered the same day.

Prepackaging requirements were established by the growers or in conjunction with the individual to whom they were marketing. The marjority were selling prepackaged herbs in bunches, in polyethylene bags, or in clear rigid plastic containers. Four marketed prepackaged fresh herbs by random weight. Those selling to restaurants tended to sell by a weighted bunch or by a specific number of stems per bunch. Cut herbs sold to supermarkets tended to be a random-weight bunch. Growers marketing dried herbs packaged by weight.

Supermarkets Questonnaire. Supermarkets are purchasing from Massachusetts and regional growers in season (Northeast growing season) and from wholesalers in the off-season (non-growing season in the Northeast). Those purchasing from wholesalers would prefer to purchase locally grown herbs rather than to buy from national growers during the off season. One supermarket was purchasing from local and national growers in season. Two out of three of produce managers were purchasing herbs in bunches as opposed to prepackaged herbs. One manager stated that loose bunches can be split into smaller bunches. Local growers tend to package a larger bunch of herbs than those purchased nationally.

Packaging appears to be a problem with herbs sold in supermarkets. Loose bunches have a short shelf life, and those prepackaged in polyethylene bags get crushed or rot. Supermarkets request that herbs

be labeled with name and a list of uses. Quality standards were rated visually: little to no insect damage, no flowers, no decay, high aroma, and good plant color. The majority were purchasing 10 or more varieties of herbs.

All of the respondants agreed that the sale of herbs has increased in the past 5 years, and this increase was attributed to the interest in ethnic cooking and to the using of more fresh herbs than dried. Those surveyed agreed the market would keep expanding although several felt not as dramatically as in previous years. Two out of three felt that a marketing association would be beneficial particularly if the association paid to educate consumers on the uses of herbs. Current problems cited were improper handling in transit, packaging, and growers and produce manager being on different delivery schedules.

Wholesalers of Fresh Herbs Questionnaire. Wholesalers of fresh herbs are purchasing from local growers during the season and from national growers in Florida, California, and Hawaii in the off-season. One wholesaler operates only during the local growing season. Those purchasing nationally would prefer to buy locally with one wholesaler stating it would depend on quality. Two of the three of wholesalers are selling equally to restaurants and supermarkets with one selling to food brokers. The area wholesalers were interested in increasing sales to existing supermarkets, restaurants, and food brokers.

All wholesalers stated that the demand for herbs has increased, and the majority felt that the present demand was not being met, particulary in the winter. Herbs in short supply were coriander, mint,

oregano, and arrugala in the summer and basil, tarragon, mint, and chives in the winter. Plant dormancy problems were stated as one reason for the winter shortages. All wholesalers were offering more than 10 varieties of herbs.

The majority required that the bunches to be of a specific weight. Quality standards were consistent with the others surveyed. One wholesaler required the herbs to be cut and delivered within 36 hours for expected shelf life. All had packing requirements that included an identification label and a list of herb uses.

Proper handling of herbs during transporation was the number one problem for wholesalers of fresh herbs. Education of produce managers on the correct postharvest techniques was another problem cited.

Wholesalers of Dried Herbs Questonnaire. The three wholesalers of dried herbs contacted were purchasing United States grown and imported herbs. Reasons for purchasing imports were that certain herbs cannot be grown in the United States, greater availability, and price. Wholesalers were buying from brokers or direct from the grower with one company also purchasing from foragers. All had United States growers under contract. Two wholesalers had growers packets available to those growing for them. Quality controls required included checking the percent oil content, cleanliness, ratio of leaves to stems, dryness of the plant material, proper storage conditions, and the maintenance of healthy plants prior to harvesting. Companies often request a sample prior to shipment. Packing requirements included a minimum weight (i.e. 25 lb.), delicate material packed in

boxes, and other dried material packaged in polyethylene bags and shipped in boxes.

All the dried wholesalers agreed that the demand for herbs has increased over the past 5 years and that the present United States growers were not meeting the demand. The wholesalers stated that the United States grower could obtain a greater share of the market by matching the price of imported dried herbs, producing a higher quality product, and growing certified organic herbs. Dried wholesalers were also concerned with the herbs coming into the United States from the herb fields near the Chernobyl nuclear accident, Food and Drug Administration regulations on medicinal herbs, obtaining consistent quality of imported herbs, organic herbs being fraudulently labeled, and imported herbs being irradiated or fumigated.

CHAPTER V

DISCUSSION

Herb Industry Survey

The preliminary growers survey indicated the industry that felt the greatest handicap to production was lack of knowledge about herbs. A stronger information channel was needed to disseminate current information on production techniques, pesticides and herbicide information, sources of plant material, marketing strategies, government and state regulations, current publications, and other pertinent topics.

The profile of an herb grower in the northeast United States was one who had between one and five acres of herbs, who grew herbs in the field or in the greenhouse, and who grew a combination of culinary, aromatic, and medicinal herbs. Growers tended to use an organic fertilizer, and the rate and application was based on personal preference rather than on scientific research. Fertilizaton studies appear warrented to determine the type of fertilizer to apply; the fertilizer ratios; the amount to apply, and the stage of plant growth to apply fertilizer. Growers in container herb production utilized a greenhouse soil mix rather than a soilless mix .

Growers gave the following herbs and reasons, respectively, that they should be studied: lavender-winter hardiness problems; rosemary-diffculty in wintering over inside; wormwoods and Origanum-confusions in nomenclature; wormwood-pesticide informantion; greek oregano-sources of true seed; propagation time for individual herbs.

Cultural Studies

The results of the cultural studies indicated that the highest foliar yields were obtained at the narrow row widths 25 cm (Exp. 1) and 15 cm (Exp. 2) and at close plant spacing within the row (10 cm), Experiments 1 and 2. Foliar yields increased as the plant population per unit area increased up to the maximum population tested 40 plants/m^2 (Exp. 1) and 68 plants/m^2 (Exp. 2). Other investigators (5,9,21,50) have recommended row widths of 12.5 to 75 cm and plant spacings of 15 to 20 cm.

Foliar yields increased as planting density increased and as nitrogen rates increased, concurring with results of other investigators (5,9,24). Nitrogen levels appear to affect yields later in the growing season (weeks 8 and 10), probably due to increased plant competiton for nitrogen later in the season. Maximum foliar yields were obtained with the highest rate of nitrogen tested (120 kg/ha). Atanassov (2) observed that a nitrogen rate of 140 kg/ha did not enhance foliar yields. Several reseachers applied a split application of nitrogen at the time of planting and later in the season. An application of nitrogen later in the season appears unnecessary due to no effect of fertilizer at 10 weeks after germination.

Nitrogen had no significant effect on the diameter of terminal umbel, this differs from the results of Singh et al (39) and Hornok(24) observed that 45 kg/ha nitrogen reduced the number of umbels and seed yield. Umbel diameter increased as the plant population decreased, apparently because the plants are spaced further apart allowed increase development of the umbel. Gupta (21) observed no correlation between the size and number of the umbels and higher seed yields. Singh et al. (39) concluded that phosphorus had more of an affect on seed yield than nitrogen.

Ethalfluralin was the most effective herbicide for use on fresh marketed dill. Ethalfluralin applied pre plant incorporated and as a preemergence herbicide provided effective weed control with minimal crop injury and gave the greatest yields. Our results are in agreement with those reported by Frieson et al. (16) and Wall et al. (48).

Our investigations indicated that linuron caused serious crop injury to dill, reducing yields and being unacceptable as a preemergence or post emegence herbicide for use on fresh marketed dill. Linuron (post) and trifluralin (PPI) reduced plant height and yields. However, other investigators (13,16,35,47,48) have observed that trifluralin provides excellent weed control while maintaining high yields. Further investigations might include trifluralin in combination with other post emergence herbicides; such as diclofop and sethoxydim.

Marketing Surveys

The marketing survey indicated an immediate need for postharvest research with fresh herbs, including proper handling of fresh herbs in transit and on the shelf and for cost effective packaging that could increase the shelf-life. Alternatives to the currently used polyethylene bags and loose bunches need to be investigated. Joyce et al. (30) and Hruschka et al. (27) have conducted postharvest studies on specific herbs and found that postharvest storage temperatures are the single most important factor in maintaining quality. Joyce et al (30) suggested "pillow packs" (plastic bags which are partially inflated when sealed) as an alternative packing technique.

Five out of seven supermarkets and fresh herb wholesalers would prefer to buy regionally grown herbs during the fall and winter months. Greenhouse production systems need to be developed, and economic cost analyses of growing herbs in the Northeast during the fall, winter, and early spring need to be investigated.

Dried wholesalers state there is a demand for United States grown, high quality, certified organic dried herbs because of the inconsistent quality of imported herbs. Dried herb wholesalers need to inform growers of their needs, specifically cultural recommendations, quality standards, packaging requirements and a listing of herbs in demand.

The survey asked all respondents if a marketing association would be beneficial to the herb industry. Most respondents agreed that there was a need for a marketing association, and in 1986 the International Herb Growers and Marketers Association was formed at the

Herb Growers Conference to promote the production and marketing of herbs and herb related products. The organization should serve as informational center for new cultivating and growing techniques, understanding state and federal laws and regulations, Food and Drug regulations, marketing stratagies, and help with other related topics. This organization has the potential to have a major impact on the herb industry as a disseminator of information.

APPENDIX

Table 11. Responses to the Herb Industry Survey

1. My firm 23 grows 18 wholesales 27 retails 7 other.

2. I grow: 30 culinary; 27 medincinal; 30 aromatic herbs.

3. Most of my herbs are grown for sale as:

   26 potted plants; 6 fresh cut; 11 dried leaves;
   9 seeds; 12 products with herbs.

4. Our herbs are grown: 23 in a greenhouse; 24 as a field crop;
   17 year round.

5. I use a traditional: organic fertilizer 19
   inorganic fertilizer 6
   combination 6

6. My approximate fertilizer ratio is: (example 5-10-10)

   7 - 20:20:20
   4 - 5:10:10
   2 - 10:10:10
   12 - miscellanous (bonemeal, compost, fish emulsion)

7. Applications of the fertilizers are made: 2 weekly;
   7 bi-monthly; 2 monthly; 11 yearly; 9 other.

8. The herbs are grown in 22 soil or 12 soilless mixes.

9. I currently have ____ acres of herbs in production.

   9 - under 1 acre
   13 - 1 to 5 acres
   2 - 6 to 10 acres
   1 - 10 acres plus

10. Our five most profitable herbs are:

    1. 17 - Rosemary
    2. 15 - Tarragon
    3. 15 - Lavender
    4. 15 - Oregano
    5. 10 - Basil

11. The following herbs should be studied and why?

Lavender - winter hardiness problem
Greek Oregano - sources of true seed
Rosemary - difficulty in wintering over indoors
Wormwoods/Origanium- confusions in nomenclature
Individual propagation time for specific herbs

12. I feel the greatest problem for the herb industry is:

Lack knowledge, botanical mislabeling, competion from imports, misinformation from uninformed growers and retailers, quality standards

Name of firm: (optional)

Table 12. Responses to the Wholesalers of Fresh Herbs Marketing Questionnaire

---

1. Purchasing herbs from:

1	Mass. grower
2	regional grower
1	national grower
1	jobber
1	other

2. If purchasing herbs nationally, would you prefer to buy locally?
   2 - yes
   1 - depends on quality and customer demand

3. Selling to:(rank as to sales volume, 1=highest)

2-#1, 1-#2	supermarkets
	vegetable/fruit stores
1-#2	food brokers
2-#1,1-#2	other restaurants

4. Into what market would you like to see sales expalded?

   Expand existing restaurants and supermarkets, Food brokers
   Broker locally grown herbs in the winter

5. Are you buying herbs:

1	seasonally
3	year round

6. Do you buy regionally or nationally grown herbs when necessary?

2	regionally/seasonally
1	nationally/seasonally
1	regionally/year round
1	nationally/year round

7. Has the demand for herbs increased/decreased over the past 5 years?

4	increased
-	decreased

8. Projected sales:

   Winter greenhouse production of herbs

9. Is the present supply meeting the demand?

Not in the winter

10. Are there any herbs in short supply? (specify)

Off season - basil, tarragon, chives, mint
Summer - oregano, mint, coriander, arugala

11. What herbs are you currently marketing:

4	basil	4	sage
3	chives	1	savory
3	coriander	4	spearmint
4	dill	4	tarragon
4	oregano	4	thyme
3	parsley	-	watercress
4	rosemary	7	other(s) (arugala, bay, burnet, chervil, edible flowers sorrel)

12. Do you have any packaging requirements: 4 - yes, 0 - no

3	weighted bunch	
1	random weight	
1	bulk ie. bushel	
-	size limitations	ie: specific height limitations

13. Do you have any quality standards?

3 - visually standards
1 - cut and delivered within 36 hours and must last one week on the shelf

14. Would a herb marketing association be beneficial?

2 - yes
2 - not sure

15. Current problems associated with marketing herbs:

3 - transportation problems (perishability, shipping expense)
1 - education of produce managers and transportation handlers, high demand for herbs, labeling of herbs

Table 13. Responses to the Wholesalers of Dried Herbs Marketing Questonnaire.

---

1. Are you purchasing dried herbs:
   - 3 U.S. grown
   - 3 imports

2. If imports, why:
   - 1 price
   - 2 greater availabiltiy
   - - quality
   - 2 can not be grown in the United States

3. Who are you purchasing from:
   - 3 grower
   - 2 jobber
   - - wholesaler
   - 1 foragers

4. Are growers under contract?
   2 - yes
   1 - no

5. What quality controls are required by your company?

   Healthy plants prior to drying, cleanliness (% leaves to stems), oil content, how well dried the plant material is

6. Do you have specific packing requirements?

   Delicate material needs to be packed in boxed, other material packaged bulk (25 lbs minimum) in polyethylene bags

7. Has the demand for herbs increased/decreased over the last 5 years?
   3 - yes
   0 - no

8. Projected sales:

9. Is the present U.S. supply meeting the demand?
   0 - yes
   3 - no

10. Are there any herbs in short supply (specify)?

    Oregano, basil, sage, chamomile, feverfew, spearmint

11. Who would a grower contact if interested in growing sizable quantities of herbs?

12. How could a U.S. grower obtain a greater share of the dried market?

Match price of imports, produce a higher quality product, grow certified organic herbs

13. Would a marketing association be benefical:
    3 - yes
    0 - no

14. Current problems associated with marketing herbs:

Consistent quality of imports, irradiation of herbs, Food and Drug Admin. regulations of medicinal herbs, production costs, What is defined as organic in other countries?

Table 14. Responses to the Supermarkets Marketing Questonnaire

---

1. Who are you purchasing fresh herbs from: (rank)
   - 1 Mass. grower
   - 2 regional grower
   - 1 national grower
   - 2 wholesaler (note: purchase from in winter only)
   - ____ other

2. If you are purchasing nationally, would you prefer to buy Mass. grown?

3. Availability of herbs:
   - 3 seasonally
     - 2 locally
     - - regionally
     - 1 nationally
   - 3 year round
     - - locally
     - 1 regionally
     - 2 nationally

4. Do you purchase:
   - 2 bulk
   - 1 pre-packaged

5. Unit description:
   - - bulk ie. bushel basket
   - 1 weighted bunch
   - 2 random weight
   - - size limitations ie: height of plant

6. Do you have any quality standards?

   Visually rate; no decay, no flowers, little to none insect damage

7. What herbs are currently buying:

3	basil	3	sage
3	chives	1	savory
2	coriander	3	spearmint
3	dill	3	tarragon
3	oregano	3	thyme
2	parsley	2	watercress
2	rosemary	2	other(s) (arugala, lemon grass)

8. Are there any herbs in short supply?

    0 - yes
    3 - no

9. Has the sale of herbs increased/decreased in the past 5 years?

    3 - increased
    0 - decreased

10. Where do you feel the market is going?

    3 - keep on growing

11. Would a herb marketing association be beneficial?

    1 - yes
    2 - not necessarily

12. Current problems associated with marketing herbs:

    Transit problems, growers and supermarkets on different delivery schedules, packaging problems/short shelf life, supermarkets need a way to identify herbs, consumer information of how to use herbs

Table 15. Responses to the Growers Marketing Questonnaire

---

1. Do you market herbs:
   - 5 fresh
   - 3 dried

2. How are you marketing the herbs you grow:(rank as to sales volume, 1=highest)

   - 1-#2 supermarkets
   - 3-#1, 1-#2 wholesaler
   - - jobber
   - 1-#1 retail

   - 1-#1, 2-#2 restaurants
   - _____ farm stands
   - _____ other (farmers markets, health food & gourmet shops)

3. Are you growing:

   - 4 seasonally
   - 3 year round

4. Are you selling:
   - 2 bulk
   - 5 pre-packaged

5. Would there be a market for year round, locally grown herbs?

   4 - yes
   1 - no (high production costs)

6. Unit description:
   - - bulk ie. bushel basket
   - 3 weighted bunch
   - 4 random weight
   - - size limitations ie: specific height requirements

7. Who has established the specific pre-packaged requirements?

   5 - grower
   1 - restaurant
   2 - supermarkets

8. Are there any quality standards you are required to follow?

   6 - visual standards, 1 - taste, 1 - cut/delivered same day

9. What herbs are you growing:

7	basil	7	sage
6	chives	3	savory
5	coriander	7	spearmint
7	dill	6	tarragon
7	oregano	6	thyme
5	parsley	1	watercress
7	rosemary	5	other(s) (comfrey, sorrel, peppercress, chervil arugala)

10. Have you or are you planning to increasing production?

6 - yes
1 - no

11. How long have you been growing herbs?

3 - five years or less
4 - 6 to 10 years

12. Do you feel the demand for herbs will increase or decrease? Why?

5 - increase
1 - decrease

13. Is the market approaching saturation?
1 - yes
4 - no
1 - somewhat

14. Are you interested in selling bulk dried herbs?

4 - yes
1 - no

15. What market would you like to expand into and what is the reason holding you back?

supermarkets, mailorder, retail market, expand outside the region

16. Current problems associated with marketing herbs:

competition, not being able to grow enough, delivery schedules, packaging and shelf life problems, labor intensive crops

Table 16: Analysis of Variance for 6 weeks after germination (Exp. 1).

A. Dill Height

Source of Variation	df	M.S.	F
Plant density (P)	8	4	0.57 n.s
Replicate (R)	2	292	41.71 **
Sampling error	135	7	
Experimental error	16	7	
Total	161		

B. Fresh Dill

Source of Variance	df	M.S.	F
Plant density (P)	8	6351	5.79 **
Replicate (R)	2	963	0.88 n.s.
Sampling error	27	719	
Experimental error	16	1097	
Total	53		

C. Dried Dill

Source of Variance	df	M.S.	F
Plant density (P)	8	130	6.84 **
Replicate (R)	2	15	0.79 n.s.
Sampling error	27	12	
Experimental error	16	19	
Total	53		

Table 17: Analysis of Variance Table for 8 weeks after germination (Exp. 1).

A. Dill Height

Source of Variation	df	M.S.	F
Plant density (P)	8	135	0.92 n.s.
Replicate (R)	2	895	6.09 **
Sampling error	135	116	
Experimental error	16	147	
Total	161		

B. Fresh Dill

Source of Variation	df	M.S.	F
Plant density (P)	8	287062	3.06 *
Replicate (R)	2	247212	2.64 n.s.
Sampling error	27	77481	
Experimental error	16	93712	
Total	53		

C. Dried Dill

Source of Variation	df	M.S.	F
Plant density (P)	8	4420	3.74 *
Replicate (R)	2	2804	2.37 n.s.
Sampling error	27	856	
Experimental error	16	1181	
Total	53		

Table 18: Analysis of Variance Table for 10 weeks after germination (Exp. 1).

A. Dill Height

Source of Variation	df	M.S.	F
Plant density (P)	8	101	0.86 n.s.
Replicate (R)	2	772	6.54 **
Sampling error	135	124	
Experimental error	16	118	
Total	161		

B. Fresh Dill

Source of Variation	df	M.S.	F
Plant Density (P)	8	2690037	20.31 **
Replicate (R)	2	423782	3.20 n.s.
Sampling error	27	212190	
Experimental error	16	132423	
Total	53		

C. Dried Dill

Source of Variation	df	M.S.	F
Plant density (P)	8	73522	24.18 **
Replicate (R)	2	9702	3.19 n.s.
Sampling error	27	4346	
Experimental error	16	3041	
Total	53		

Table 19: Analysis of Variance Table for 12 weeks after germination (Exp. 1).

A. Dill Height

Source of Variation	df	M.S.	F
Plant density (P)	8	176	1.10 n.s.
Replicate (R)	2	551	3.44 *
Sampling error	135	161	
Experimental error	16	160	
Total	161		

B. Fresh Dill

Source of Variation	df	M.S.	F
Plant density (P)	8	8177502	9.38 **
Replicate (R)	2	3520920	4.04 *
Sampling error	27	1180664	
Experimental error	16	871490	
Total	53		

C. Dried Dill

Source of Variation	df	M.S.	F
Plant density (P)	8	350326	9.78 **
Replicate (R)	2	98795	2.76 n.s.
Sampling error	27	41702	
Experimental error	16	35804	
Total	53		

Table 20: Analysis of Variance Table for 13 weeks after germination (Exp. 1).

A. Dill Height

Source of Variation	df	M.S.	F
Plant density (P)	8	647	1.64 n.s.
Replicate (R)	2	351	0.89 n.s.
Sampling error	135	181	
Experimental error	16	395	
Total	161		

B. Fresh Dill

Source of Variation	df	M.S.	F
Plant density (P)	8	20125451	9.97 **
Replicate (R)	2	407451	0.20 n.s.
Sampling error	135	1168191	
Experimental error	16	2018724	
Total	161		

C. Dried Dill

Source of Variation	df	M.S.	F
Plant density (P)	8	948377	17.04 **
Replicate (R)	2	40868	0.73 n.s.
Sampling error	133	86899	
Experimental error	16	55664	
Total	159		

Table 21: Analysis of Variance for 13 weeks after germination (Exp. 1).

A. Number of Axillary Branches

Source of Variation	df	M.S.	F
Plant density (P)	8	3	0.43 n.s.
Replicate	2	3	0.43 n.s.
Sampling error	135	2	
Experimental error	16	7	
Total	161		

B. Diameter of Terminal Umbel

Source of Variation	df	M.S.	F
Plant density (P)	8	10	1.25 n.s.
Replicate	2	17	2.13 n.s.
Sampling error	135	4	
Experimental error	16	8	
Total	161		

Table 22: Analysis of Variance Table for 15 weeks after germination (Exp. 1).

A. Dill Height

Source of Variation	df	M.S.	F
Plant density (P)	8	298	0.99 n.s.
Replicate (R)	2	381	1.15 n.s.
Sampling error	135	236	
Experimental error	16	332	
Total	161		

B. Fresh Dill

Source of Variation	df	M.S.	F
Plant density (P)	8	4373686	2.51 n.s.
Replicate (R)	2	1550667	0.89 n.s.
Sampling error	27	883679	
Experimental error	16	1742428	
Total	53		

C. Dried Dill

Source of Variation	df	M.S.	F
Plant density (P)	8	264316	2.22 n.s.
Replicate (R)	2	92821	0.78 n.s.
Sampling error	27	57464	
Experimental error	16	118959	
Total	53		

Table 23: Analysis of Variance for 6 weeks after germination (Exp. 2).

A. Dill Height

Source of Variation	df	M.S.	F
Plant Density (P)	5	132	3.14 *
Fertilizer (F)	2	114	2.71 n.s.
Replicate (R)	2	943	22.45 **
PF	10	56	1.33 n.s.
Sampling error	108	48	
Experimental error	34	42	
Total	161		

B. Fresh Dill

Source of Variance	df	M.S.	F
Plant Density (P)	5	4235498	39.14 **
Fertilizer (F)	2	204024	1.89 n.s.
Replicate (R)	2	340232	3.14 n.s.
PF	10	259466	2.40 *
Sampling error	108	89741	
Experimental error	34	108222	
Total	161		

C. Dried Dill

Source of Variation	df	M.S.	F
Plant Density (P)	5	45564	35.00 **
Fertilizer (F)	2	2031	1.56 n.s.
Replicate (R)	2	4211	3.23 n.s.
PF	10	2889	2.22 *
Sampling error	108	869	
Experimental error	34	1302	
Total	161		

Table 24: Analysis of Variance for 8 weeks after germination (Exp. 2).

A. Dill Height

Source of Variation	df	M.S.	F
Plant density (P)	5	204	1.84 n.s.
Fertilizer (F)	2	328	2.96 n.s.
Replicate (R)	2	209	1.88 n.s.
PF	8	253	2.28 *
Sampling error	108	74	
Experimental error	34	111	
Total	162		

B. Fresh Dill

Source of Variation	df	M.S.	F
Plant Density (P)	5	80159760	22.77 **
Fertilizer (F)	2	1345776	0.38 n.s.
Replicate (R)	2	1388093	0.39 n.s.
PF	8	9510528	2.70 *
Sampling error	108	1179180	
Experimental error	34	3519908	
Total	162		

C. Dried Dill

Source of Variation	df	M.S.	F
Plant density (P)	5	908161	23.59 **
Fertilizer (F)	2	7239	0.19 n.s.
Replicate (R)	2	9505	0.25 n.s.
PF	10	97449	2.53 *
Sampling error	108	11972	
Experimental error	34	38504	
Total	161		

Table 22: Analysis of Variance Table for 15 weeks after germination (Exp. 1).

A. Dill Height

Source of Variation	df	M.S.	F
Plant density (P)	8	298	0.99 n.s.
Replicate (R)	2	381	1.15 n.s.
Sampling error	135	236	
Experimental error	16	332	
Total	161		

B. Fresh Dill

Source of Variation	df	M.S.	F
Plant density (P)	8	4373686	2.51 n.s.
Replicate (R)	2	1550667	0.89 n.s.
Sampling error	27	883679	
Experimental error	16	1742428	
Total	53		

C. Dried Dill

Source of Variation	df	M.S.	F
Plant density (P)	8	264316	2.22 n.s.
Replicate (R)	2	92821	0.78 n.s.
Sampling error	27	57464	
Experimental error	16	118959	
Total	53		

Table 23: Analysis of Variance for 6 weeks after germination (Exp. 2).

A. Dill Height

Source of Variation	df	M.S.	F
Plant Density (P)	5	132	3.14 *
Fertilizer (F)	2	114	2.71 n.s.
Replicate (R)	2	943	22.45 **
PF	10	56	1.33 n.s.
Sampling error	108	48	
Experimental error	34	42	
Total	161		

B. Fresh Dill

Source of Variance	df	M.S.	F
Plant Density (P)	5	4235498	39.14 **
Fertilizer (F)	2	204024	1.89 n.s.
Replicate (R)	2	340232	3.14 n.s.
PF	10	259466	2.40 *
Sampling error	108	89741	
Experimental error	34	108222	
Total	161		

C. Dried Dill

Source of Variation	df	M.S.	F
Plant Density (P)	5	45564	35.00 **
Fertilizer (F)	2	2031	1.56 n.s.
Replicate (R)	2	4211	3.23 n.s.
PF	10	2889	2.22 *
Sampling error	108	869	
Experimental error	34	1302	
Total	161		

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