Effect of Single Basal Application of Polyolefin Coated Fertilizer on Growth and Yield of Green Peppers

Tohoku Journal of Agricultural Research
Vol. 49 No. 1-2, September 1998
Printed in Japan

Effect of Single Basal Application of Polyolefin Coated Fertilizer on Growth and Yield of Green Peppers

Attila OMBODI, Masahiko SAIGUSA and Kyoichi SHIBUYA

Experimental Farm of Tohoku University, Kawatabi, Naruko, Tamatsukuri, Miyagi, 989-6711, Japan

(Received, July 16, 1998)

Summary

The conventional fertilization of field grown green peppers consists of a basal application and several topdressings. With a single basal application of polyolefin coated fertilizer (POCF), topdressing can be eliminated, thus labor costs can be reduced. In this study, a single basal application of POCF was compared to the split application of readily available fertilizer (RAF) in 1996 and 1997. In 1996, plants given POCF were taller and gave better early and total yield than those given RAF treatment. In 1997, the yield was the same for both RAF and POCF, however in the early growth stages, POCF gave better yield than did RAF. Fruits given POCF had higher average vitamin C content than did those given RAF. The nitrogen, phosphorus and potassium concentrations of fruit from the POCF plants were also higher in this year. From the above, it can be concluded that a single basal application of POCF fertilizer is recommended, as a labor and energy saving fertilization method for field grown green peppers.

As most vegetable crops require a continuous supply of nitrogen for maximum yield, large amounts of nitrogen are used in vegetable production (Sharma, (1)). As most vegetable plants cannot tolerate a high salt concentration (Yamaguchi, (2)), the split application of fertilizers is necessary. After the invention of slow/controlled release fertilizers (SRF/CRF), a great deal of research was done on the possible use of these materials in growing vegetables (Sharma, (1) ; Maynard and Lorenz, (3)). CRFs can decrease labor and energy costs due to the elimination of topdressings and can decrease N leaching. Even though in regard to seedling raising and ornamental tree nurseries, however the use of CRFs became wide-spread, these materials did not gain significant importance in vegetable growing due to the costs involved. As Sharma (1) noted, very expensive CRF materials offer little or no economic advantage over conventional materials for vegetable crop production.

In Florida, many studies were performed on the possible use of CRFs for field grown peppers. Everett (4) noted that a single basal band application of CRF is a possible fertilization method for field grown peppers, without decreasing the yield. Locascio et al. (5) found that SRF maintained a high available soil-N level throughout the growing period and produced the same yield to split application of RAF. Csizinszky (6) observed that the incorporation of CRF into the fertilization of field grown bell peppers resulted in higher early and total yields. Miyashita and Shiobara (7) put the entire amount of nutrients into the nursery pot in the form of POCF, and got a larger early yield and a similar total yield to the conventional fertilization method.

In Miyagi Prefecture the advised nitrogen fertilizer rate for field grown green peppers is 25-35 g nitrogen/m^2 and the advised fertilization method consists of a basal application and 4-5 topdressings. With a single basal application of POCF, these topdressings could be eliminated and labor costs could be reduced. In regard to cost considerations; according to our calculations, in Japan the extra cost of the use of POCF per m^2 is less than the price of two green peppers, even without calculating the possible labor and energy savings.

The objective of this study was to compare the effects of a single basal application of POCF and those of split application of RAF on the growth and yield of green pepper.

Materials and methods

Experiments were conducted in 1996 and 1997 at the experimental farm of Tohoku University, which is in a cold region of Miyagi Prefecture. The soil is Alic Pachic Mellanudand in this farm. For both years, superphosphate (343 g/m^2 in 1996 and 229 g/m^2 in 1997) and dolomite (300 g/m^2 in 1996 and 200 g/m^2 in 1997) was incorporated into the soil before the experiment, as a soil amendment.

Table 1 shows the meteorological data for the two growing seasons. The biggest difference between the two experimental years was the amount of rainfall, which was twice as much in 1997 as in 1996. In the second year there was more

TABLE 1. *Main Meteorological Characteristics for the Two Growing Seasons*

	1996		1997	
	first month	whole period	first month	whole period
Daily average air temperature (°C)	16.6	17.7	14.8	18.0
Sum of daily average air temperature (°C)	498	2,760	445	2,900
Sum of rainfall (mm)	41	452	243	955
Sum of sunshine hours	16	434	64	541

TABLE 2. *Design of Fertilizer Application*

	1996		1997	
	RAF	POCF	RAF	POCF
Fertilizer	Compound NPK Microelements	POC-NPK-Mg-ME (13-13-13-2-ME)-70	Ammonium-nitrate Superphosphate Potassium-sulphate	POC-NPK (14-12-14)-70
$N-P_2O_5-K_2O$ rate (g/m^2)	30-30-30	30-30-30	30-25.7-30	30-25.7-30
Basal application (g/m^2)	10-10-10	30-30-30	10-25.7-10	30-25.7-30
Application method	Broadcasting	Broadcasting	Broadcasting	15 cm wide band at 15 cm depth
Time of topdressing (days after planting)	13, 41, 69, 89	—	37, 66, 98, 131	—

RAF = Readily available fertilizer, POCF = Polyolefin coated fertilizer, ME = microelements

rain and lower temperatures during the first month, which is the period of seedling establishment.

In both years, the split application of RAF was compared to a single basal application of polyolefin coated-NPK (POC-NPK) fertilizer. Table 2 shows the details of the fertilization. In the first year, a fertilization method (recommended for this prefecture), was used (9) for the use of RAF. According to the data got from the first experiment, fertilization was modified for this treatment in the second year : compound fertilizer was replaced with one component fertilizers and topdressings were applied later. In both years topdressing was applied four times with equal fertilizer doses.

In both years green pepper (*Capsicum annuum* L. cv. Nishiki) seedlings were transplanted into a field at 2 plants/m^2 density (9). The distance between the rows was 110 cm and the distance between two plants was 45 cm. Plants were raised in beds. Transplanting was done on May 31, 1996 and on May 19, 1997. Harvest was begun 50 days after transplanting and continued for more than three months in both years.

Three replications were used. Five plants formed a plot, and the central three plants were measured. The color of young fully developed leaves was measured by a Minolta SPAD 502 colorimeter. Plant length was measured at 2-3 week intervals throughout the growing period. Young green fruits (weighing 35-45 g) were harvested at 3-7 day intervals. In both years there were no significant differences in average fruit weight between the treatments, thus, changes in the number of fruits and the yield (kg/m^2) showed the same tendency.

The dry matter content of the whole fruits was determined monthly. At the end of the growing period, every remaining fruit was harvested and the fresh weight and dry weight of the vegetative parts (stems and leaves) were measured. Following wet digestion, the nitrogen, the phosphorus, and the potassium content of the dried fruit and plant samples were determined. Nitrogen was measured with a micro Kjehldahl method, phosphorus was measured with the molybdenum blue method, and potassium was measured with an atomic adsorption spectrophotometer. The vitamin C content in the fruit flesh of fruit weighing 35-40 g, was measured monthly in the second year. Vitamin C concentration was measured with a MERCK RQflex instrument, following extraction with a metaphosphoric acid-acetic acid solution (AOAC (8)) and filtered through a glass fiber filter (GA100, Advantec).

During the second year, the N releasing pattern of POC-NPK (14-12-14)-70 fertilizer was determined. Net bags (each filled with 3.00 g of fertilizer), were placed in the soil at the same place as the fertilizer band. Three bags were taken out at every topdressing and at the end of the experiment. The remaining N content of the fertilizer was measured using the micro Kjehldahl method.

Results and discussion

In 1996, plants from POCF plots became taller (Fig. 1), than those from RAF plots. This difference developed between 30 and 80 days after planting. In the second half of the growing season the differences between the two treatments remained relatively constant. There were no differences in leaf color for the two treatments throughout the growing period (data not shown). This indicates that there were no significant differences in leaf nitrogen concentration between the

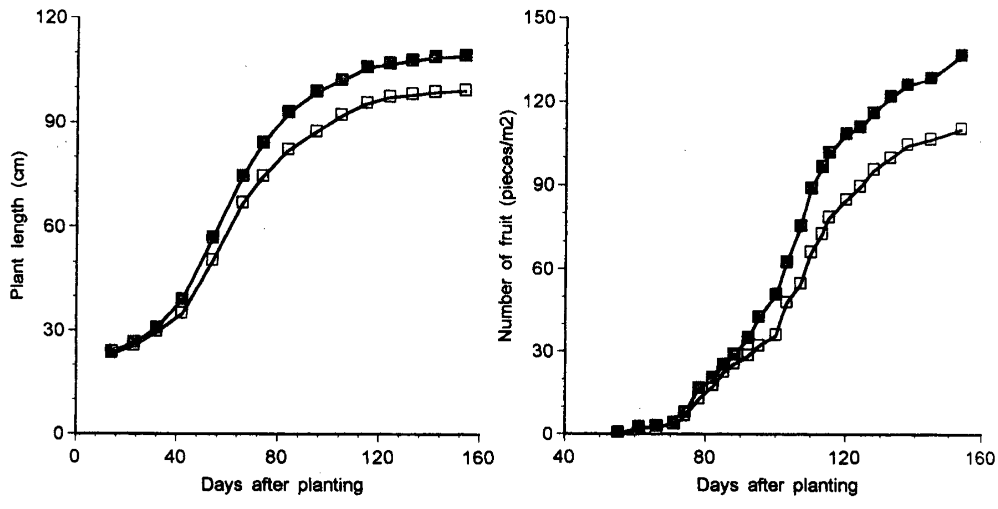

FIG. 1. Plant length and cumulative yield (number of fruit) in 1996.
—■— Polyolefin coated fertilizer —□— Readily available fertilizer

two treatments throughout the entire growing season, despite the bigger green mass in the POCF plots.

Cumulative yield (number of fruit) in 1996 (Fig. 1) was similar in tendency to that for plant length. Differences between the two developed during the first half of the harvesting period, and then this difference increased slightly during the second half of the harvesting period. Plants from POCF plots eventually produced about 20% more fruits than those from RAF plots.

There were no significant differences in case for the nitrogen, phosphorus, and potassium contents of stems and leaves between the two treatments (Table 3). The main reason for the bigger yield in POCF plots is the higher nitrogen (with 24%), phosphorus (with 42%) and potassium (with 27%) uptake (Table 3). The larger nutrient uptake resulted in larger stem and leaf weight and, thus bigger photosynthetic activity. The larger vegetative weight resulted in a higher fruit yield. The total fresh weight and dry weight production of the POCF plots was 20% and 26% higher, respectively, than those for RAF plots (Table 4).

The nitrogen releasing patterns for the POC-NPK (14-12-14)-70 fertilizer among field conditions during the experiment in 1997, show a hyperbolical (rather than linear) tendency (Fig. 2). In this experiment, this fertilizer needed about 2250°C (90 days at constant temperature of 25°C) cumulative temperature to release 80% of its nitrogen content, which is 30% more than the theoretical value (1750°C, 70 days) (Shoji and Gandeza, (10)). Fig. 3 shows the calculated N release patterns for RAF and POCF during the 1997 experiment. During the first two months there was much more available nitrogen in the RAF than in the POCF plots. Eventually about 10% less nitrogen was released in the POCF than in the RAF plots.

TABLE 3. *Nitrogen, Phosphorus and Potassium Contents and Uptakes of Green Peppers*

	1996		1997	
	RAF	POCF	RAF	POCF
N content of stems+leaves (mg/gDW)	18.7±0.37*	19.6±0.56	2.31±0.36	25.0±0.86
N content of fruits (mg/gDW)	24.2±0.34	21.8±0.28	24.9±0.21	26.8±0.23
N uptake (g/m^2)	13.6±2.08	16.9±0.40	15.8±0.68	16.9±0.46
P content of stems+leaves (mg/gDW)	1.59±0.16	1.55±0.14	1.53±0.22	1.68±0.14
P content of fruits (mg/gDW)	3.15±0.06	3.67±0.07	3.34±0.03	3.51±0.03
P uptake (g/m^2)	1.53±0.22	2.18±0.04	1.72±0.08	1.78±0.07
K content of stems+leaves (mg/gDW)	33.7±1.53	33.6±1.01	37.3±1.50	35.6±1.30
K content of fruits (mg/gDW)	35.1±0.83	33.8±0.64	33.3±0.06	35.0±0.31
K uptake (g/m^2)	21.5±3.00	27.4±0.69	22.9±0.70	22.9±0.70

*Values represent the mean±standard error
RAF=Readily available fertilizer, POCF=Polyolefin coated fertilizer

TABLE 4. *Fresh and Dry Weight Production of Green Peppers*

		1996		1997	
		RAF	POCF	RAF	POCF
Fresh weight (g/m²)	Stems+leaves	1,280±192*	1,667±32	1,317±22	1,328±18
	Fruits	5,881±518	6,954±19	6,064±89	6,232±64
	Total	7,160±711	8,621±44	7,382±108	7,560±49
Dry weight (g/m²)	Stems+leaves	267±45	364±6	261±13	273±10
	Fruits	339±34	400±3	395±6	405±4
	Total	607±80	765±5	656±10	674±4
Dry matter %	Stems+leaves	20.74±0.50	21.88±0.50	19.79±0.001	21.11±0.003
	Fruits	5.76±0.08	5.75±0.05	6.51±0.02	6.47±0.08

*Values represent the mean±standard error
RAF=Readily available fertilizer, POCF=Polyolefin coated fertilizer

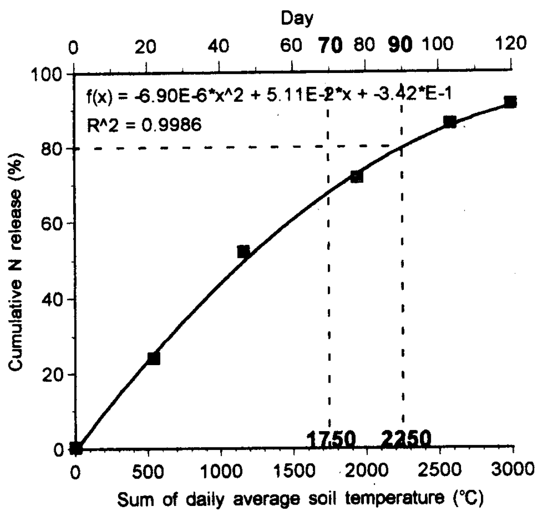

FIG. 2. N release from POC-NPK (14-12-14)-70 during the experiment in 1997.

In 1997 there were no significant differences in plant length between the two treatments (Fig. 4); there was only a small difference during the second half of the growing period, while there were no differences during the first half of the growing period. For leaf color, a small difference was observed during the first half of the growing season, which was better in the POCF plots, but later there were no significant differences between the treatments (data not shown).

Green pepper plants in POCF plots produced more fruit than those in RAF plots during the early growing peried (Fig. 4); however, the yield (number of fruits) was almost the same for both treatments at the end of the growing period.

In 1997, there were no significant differences in both fresh and dry weight

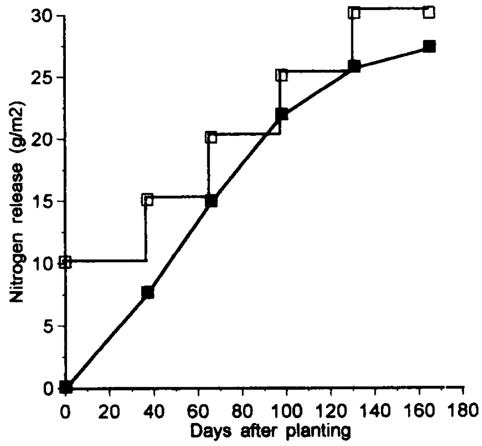

FIG. 3. Calculated N release during the experiment in 1997.
—■— Readily available fertilizer
—□— Polyolefin coated fertilizer

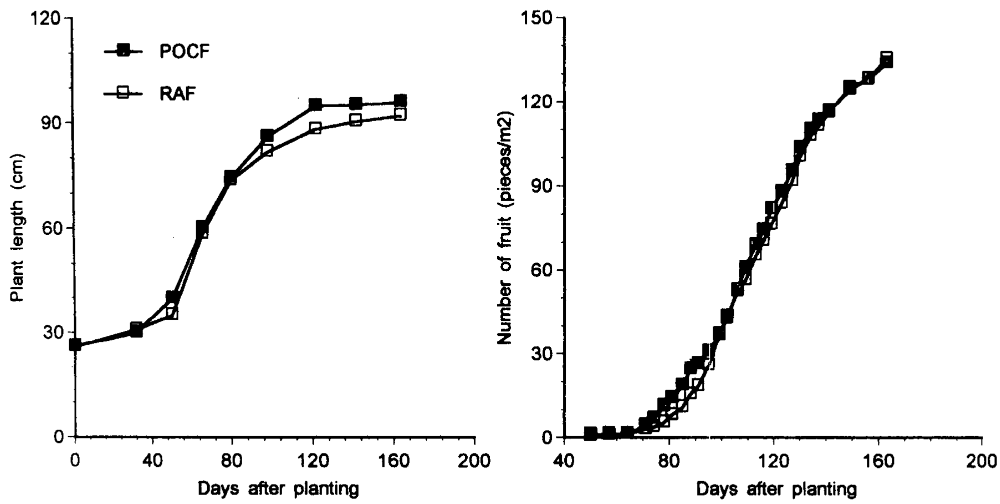

FIG. 4. Plant length and cumulative yield (number of fruit) in 1997.
—■— Polyolefin coated fertilizer —□— Readily available fertilizer

production between the two treatments (Table 4). The nitrogen uptake of plants in the POCF plots was 7% higher than that in the RAF plots, in spite of a smaller release of fertilizer nitrogen (Table 3). This can be explained by the reported higher efficiency of controlled release fertilizers (Sharma (1), Maynard and Lorenz (3)). This also mean reduction of environmental pollution caused by leaching of nitrogen fertilizer. As in 1997, there were no differences in the yield between the two treatments, the nitrogen, phosphorus and potassium concentrations in fruits from POCF plots were higher than for those from RAF plots (Table 3).

On the other hand, the most important nutritional aspect of green peppers are their vitamin C content. Fruits in POCF plots had 13% higher vitamin C content (94 mg/100 g FW) than those in RAF plots (83 mg/100 g FW) based on an average of monthly measurements. Generally it is believed that increasing the nitrogen application decreases the vitamin C content (Mozafar, (11)); however, in this experiment, plants with better nitrogen status produced fruit with higher vitamin C content. More research is needed to explain this phenomena.

According to the results of a two year experiment, a single basal application of POC-NPK fertilizer gave a higher yield during the early growing period and the better or same total yield, than split application of readily available fertilizers. This fertilization method resulted in a higher total nitrogen uptake in both years, and increased vitamin C concentration of fruit, what is the most important nutritional aspect of green peppers. Using this method, topdressing can be eliminated and thus labor and energy costs can be reduced.

A single basal application of POC-NPK fertilizer is a feasible fertilization method for field grown green peppers that can reduce both labor costs and environmental pollution caused by leaching of fertilizer nitrogen.

References

1) Sharma, C.C., Controlled release fertilizers and horticultural applications, *Sci. Hort.*, **11**, 107-129 (1979).
2) Yamaguchi, M., World vegetables: Principles, production and nutritive values, Van Nostrand Reinhold, New York (1983).
3) Maynard, D.N. and O.A. Lorenz, Controlled release fertilizers for horticultural crops, *Hort. Rev.*, **1**, 79-140 (1979).
4) Everett, P.H., Controlled release fertilizers: Effect of rates and placements on plant stand, early growth and fruit yield of peppers, *Proc. Fla. State Hort. Soc.*, **90**, 390-393 (1977).
5) Locascio, S.J., J.G.A. Fiskell and F.G. Martin, Responses of bell pepper to nitrogen sources, *J. Amer. Soc. Hort. Sci.*, **106**, 628-632 (1981).
6) Csizinszky, A.A., Yield response of bell pepper and tomato to controlled-release fertilizers on sand, *J. Plant Nutr.*, **17**, 1535-1549 (1994).
7) Miyashita, J. and T. Shiobara, Single basal application into nursery pot with controlled available fertilizer for green pepper, Abstracts of the annual meeting, *Japanese Society of Soil Science and Plant Nutrition*, **43**, 177 (1997) (in Japanese).
8) Horowitz, W. (Ed.), "*Official methods of analysis of the association of official analytical chemists*", 13th edition, AOAC, Washington (1980).
9) Miyagi Agricultural Research Center Publishing Committee, "*Noka torano maki*", Yubensha Co. (1995) (in Japanese).
10) Gandeza, A.T. and S. Shoji, Properties of polyolefin-coated fertilizers, in "*Controlled release fertilizers with polyolefin coating*", Eds. Shoji, S., and A.T. Gandeza, Konno Printing Co., Ltd., Sendai, Japan (1992).
12) Mozafar, A., Nitrogen fertilizers and the amount of vitamins in plants: A review, *J. Plant Nutr.*, **16**, 2479-2506 (1993).