

*Affectionately dedicated*

*to my beloved parents*

*Aai, Papa and*

*late. Grandfather*

*Tatya*

*.....Vivek*

ABSTRACT DIGITIZED

EFFECT OF CONCENTRATION AND NUMBER OF  
FOLIAR SPRAYS OF METHANOL ON GROWTH,  
YIELD AND QUALITY OF WHEAT

**By**

*ViveSuresh*

(Reg No.96050)

A Thesis submitted to the  
MAHATMA PHULE KRISHI VIDYAPEETH,  
RAHURI - 413 722, DIST.AHMEDNAGAR,  
MAHARASHTRA, INDIA

in partial fulfilment of the requirements for the degree

of

MASTER OF SCIENCE (AGRICULTURE)

in

AGRICULTURAL CHEMISTRY

DEPARTMENT OF AGRICULTURAL CHEMISTRY AND  
SOIL SCIENCE

POST GRADUATE INSTITUTE  
MAHATMA PHULE KRISHI VIDYAPEETH,

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2000

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APPROVED BY ADVISORY COMMITTEE :

  
(Dr. R.N. Adsule)

Chairman and Research Guide

  
(Dr. J.D. Patil)

Committee Member

  
(Dr. B.H. Khan)

Committee Member

DEPARTMENT OF AGRICULTURAL CHEMISTRY AND  
SOIL SCIENCE

POST GRADUATE INSTITUTE  
MAHATMA PHULE KRISHI VIDYAPEETH,  
RAHURI - 413 722


2000

# CANDIDATE'S DECLARATION

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Place : MPKV, Rahuri

Dated : 8 / 6 / 2000

  
(V.S. Patil)

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**Dr. R.N. Adsule**

M.Sc., Ph.D.

Professor,

Department of Agril. Chemistry

and Soil Science,

Mahatma Phule Krishi Vidyapeeth,

Rahuri - 413 722, Dist. Ahmednagar,

Maharashtra State (INDIA)

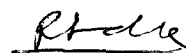
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This is to certify that the thesis entitled, "**Effect of concentration and number of foliar sprays of methanol on growth, yield and quality of wheat**", submitted to the Mahatma Phule Krishi Vidyapeeth, Rahuri for the award of the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **AGRICULTURAL CHEMISTRY**, embodies the results of a *bona fide* research carried out by **Mr. VIVEK SURESH PATIL** under my guidance and supervision and that no part of the thesis has been submitted for any other Degree or Diploma.

The assistance and help received during the course of this investigation have been acknowledged.

Place : MPKV, Rahuri

Dated : 5 / 6 / 2000.



(R.N. Adsule)

Research Guide

**Dr. S.S. Kadam**

M.Sc., Ph.d

Associate Dean,

Post Graduate Institute,

Mahatma Phule Krishi Vidyapeeth,


Rahuri - 413 722, Dist. Ahmednagar,

Maharashtra State (INDIA)

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This is to certify that the thesis entitled, "**Effect of concentration and number of foliar sprays of methanol on growth, yield and quality of wheat**", submitted to the Mahatma Phule Krishi Vidyapeeth, Rahuri for the award of the degree of **MASTER OF SCIENCE (AGRICULTURE) in AGRICULTURAL CHEMISTRY**, embodies the results of a *bona fide* research carried out by **Mr. VIVEK SURESH PATIL** under the guidance and supervision of **Dr. R.N. ADSULE**, Professor, Department of Agril. Chemistry and Soil Science, M.P.K.V., Rahuri and that no part of the thesis has been submitted for any other Degree or Diploma.

Place : MPKV, Rahuri

  
(S.S. Kadam)

Dated : 13 / 6 / 2000.

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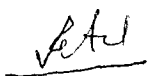
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Place : MPKV, Rahuri

Dated : 8/ 6 /2000

  
(Vivek S. Patil)

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## LIST OF ABBREVIATIONS

@	:	At the rate of
cm	:	Centimeter
CD	:	Critical difference
Cv.	:	Cultivar
DAS	:	Days after sowing
°C	:	Degree celsius
Fig.	:	Figure
g	:	Gram
ha	:	Hectare
hrs	:	Hours
kg	:	Kilogram
lit.	:	Litre
µg	:	Microgram
mg	:	Milligram
ml	:	Millilitre
viz.,	:	Namely
ppb	:	Parts per billion
ppm	:	Parts per million
/	:	Per
%	:	Per cent
q	:	Quintal
S.E.	:	Standard error
TRIA	:	Triacontanol

## ABSTRACT

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### EFFECT OF CONCENTRATION AND NUMBER OF FOLIAR SPRAYS OF METHANOL ON GROWTH, YIELD AND QUALITY OF WHEAT

By

Vivek Suresh Patil

Mahatma Phule Krishi Vidyapeeth,

Rahuri - 413 722

2000

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Research Guide	:	Dr. R.N. Adsule
Department	:	Agril. Chemistry and Soil Science

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A field experiment to study the effect of concentration and number of foliar sprays of methanol on growth, yield and quality of wheat was conducted during the *rabi* season of 1996-97 on Post Graduate Institute Farm, Mahatma Phule Krishi Vidyapeeth, Rahuri, on Sawargaon soil series (Vertic Ustrophepts). The experiment was laid out in a factorial randomized block design with sixteen treatments i.e. 4 concentrations of methanol (0, 10, 20 and 30 %) and 4 sprays at intervals of application (30, 30 + 45, 45 + 60 and 30 + 45 + 60 days after sowing) and two replications. The observations of plant growth, yield and yield contributing characters, nutrient uptake and chemical composition of grain were recorded.

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**V.S Patil**  
**MPKV,Rahuri**

**Abstract contd.....**

**AGRIL. CHEMISTRY**

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The ratio of additional benefit to additional cost of spraying of methanol (B:C ratio) decreased with increase in the concentration of methanol from 10 to 30 per cent and increase in the number of sprays from 1 to 3. The maximum B : C ratio was obtained due to one foliar spray of 20 per cent methanol at 30 DAS

The results indicated that among the different combinations of concentrations and number of foliar sprays of methanol used in the present investigation, three sprays of 20 per cent methanol at 30, 45 and 60 DAS, were superior to rest of the treatment combinations in terms of plant growth, yield and quality of wheat.

Chapter Opener Page



**INTRODUCTION**

# 1. INTRODUCTION

The need for improving the productivity of crop by optimising the levels of fertilizer and management inputs, has been an area of continued concern all over the world. The role of plant growth regulators (PGRs) in stimulating the physiological processes of plants is one of the most interesting topics of research. PGRs have been used for promoting root growth, increasing number of flowers, fruit set, fruit size and inducing early and uniform fruit ripening, etc. The use of PGRs has brought up spectacular results both in terms of yield and the quality of many agricultural crops.

The crop plants with  $C_3$  photosynthetic carbon reduction cycle pathway have been characterised with low photosynthetic efficiency. Therefore, in the recent past, the focus has been given to improve the yield and quality of  $C_3$  crop plants by use of photosynthesis improvers (Prasad *et al.*, 1991). The use of triacontanol ( $C_{30}$  alcohol) and triacontanol-based commercial products such as Mixtalol, Vipul, Paras Photosynth, etc have been reported to improve the growth, yield and quality of several agricultural crops (Suwani, 1988; Setia *et al.*, 1989; Kothale *et al.*, 1993a,b; Deotale *et al.*, 1994 a, b; Baruah *et al.*, 1997). Spraying diluted methanol, commonly known as wood alcohol, has been observed to increase the yield and improve quality of several agricultural crops (Benson and Nonomura, 1992).

Nonomura and Benson (1992) carried out experiments on methanol spraying in Arizona and California, USA. They found that foliar sprays of 10 to 50 per cent methanol increased the growth and development of C<sub>3</sub> crop plants in an arid environment. Foliar treatments of methanol resulted in increased turgidity of plants. However, direct sunlight is found to be important for the effective use of methanol spraying. Plants sprayed with nutrient supplemented methanol showed substantial increase in yield, when maintained under direct sunlight in desert agriculture. Winter crops and plants, kept under shade even when they were repeatedly treated with nutrient supplemented methanol, did not show any effect. Repeated methanol treatments with glycine caused increased turgidity and stimulated plant growth without injury under direct sunlight.

The tomato plants, sprayed with 10 per cent methanol and provided with direct sunlight, showed positive results within two weeks over control (Nonomura and Benson, 1992). The number of internodes/plant increased from 9-10 in control to 12-16 in treated plants. Also fruit development on treated tomato plants commenced 5-10 days earlier than in control. However, plants with C<sub>4</sub> metabolism did not show increase in the productivity by methanol treatment. Experiments on wheat (*Triticum durum*) also showed 50 per cent more foliage length and 35 per cent more width than that of untreated

control. The average number and weight of seeds per earhead from methanol treated plants were twice those of control.

Wheat (*Triticum aestivum* L.) is one of the most important and widely cultivated food crops in the world. It is consumed in various forms by more than 1000 million human beings in the world. The major wheat producing countries of the world are U.S.S.R., U.S.A, China, Argentina, France, India, Turkey, Italy, Canada, Australia and Pakistan. Wheat plays an important role in the Indian economy. It is the important staple food crop next only to rice and occupies about 18 per cent of the area sown under cereal crops. It contributes to about 25 per cent of the total production of cereals in the country. Total area under wheat in India during the year 1998-99 was 27.15 million ha with an annual production of 70.63 million M.T., the average yield was 2,812 kg/ha (Singhal, 1999). In Maharashtra state, the area under wheat crop during the year 1996-97 was 8.0 lakh ha with the production of about 11.67 lakh tonnes and the average production<sup>ivity</sup> ~~ion~~ 1449 kg/ha (Singhal, 1999).

Wheat is an important source of dietary carbohydrates, proteins, minerals and vitamins (Adsule and Kadam, 1986). Essential amino acid composition and the relative proportion of protein fractions determine the quality of wheat. In general, wheat proteins are deficient in lysine and to some extent in tryptophan but are relatively better in methionine than the legume proteins (Adsule, 1986). Carbohydrates, which ~~form~~ about 83 per cent of the total dry

matter, are the most abundant constituents of wheat grains. Wheat grains contain about 1.8 per cent mineral matter and are important source of vitamins like thiamin, niacin and pyridoxin (Adsule and Kadam, 1986).

The particular end use of wheat determines its quality. About 80 per cent wheat consumption in India is in the form of *chapaties*. Screening of a large number of genotypes under All-India Co-ordinated Wheat Improvement Project showed that following varieties are promising with respect to their *chapati* making quality. NI-5439, N-59, MACS-1967, MACS-1995 and N-8751 (Pharande *et al.*, 1988a).

Efforts have been made to improve the yield and quality of wheat by way of breeding superior genotypes and by improved cultural and management practices. The response of C<sub>3</sub> crops to foliar sprays of methanol under Indian conditions was studied. The beneficial effects of methanol were observed in case of wheat (Salunkhe *et al.*, 1998), safflower (Salunkhe, 1995), soybean (Patil, 1996), green gram (Adsul, 1999) and groundnut (Patil, 1996; Ombase, 1999).

In view of the importance of wheat crop in Indian diets and possible role of methanol in improving the yield and quality of C<sub>3</sub> crop plants, it was proposed to carry out further studies on the effect of methanol spraying on the growth, nutrient uptake, yield and quality of wheat grains with following objectives :

Chapter Opener Page

**REVIEW OF LITERATURE**

## 2. REVIEW OF LITERATURE

The use of plant growth regulators for improving the crop growth, nutrient uptake, yield and quality of C<sub>3</sub> crop plants has been studied by several workers. However, there are very few reports on the response of field crops to foliar application of methanol. Since, methanol acts as a photosynthesis improver, the available literature on the effect of photosynthesis improvers in general and that of methanol in particular on plant growth, nutrient uptake, yield and quality of crop plants has been reviewed in this chapter under appropriate sub-headings.

### 2.1 Plant growth

#### 2.1.1 Shoot growth

Triacntanol has been reported to have favourable growth promotive effects on groundnut crop (Deotale *et al.*, 1994a, b). Miniraj and Shanmugavelu (1987) reported that application of 2 ppm triacntanol at full bloom stage enhanced the shoot growth of chilli. Suwani (1988) obtained maximum increase in plant growth of chilli with 3.0 ml/lit concentration of Mixtalol. Increased size of cabbage (twice over control) due to repeated treatment of 20 per cent methanol and increased turgidity in cotton leaf due to 30 per cent methanol were reported by Nonomura and Benson (1992). Patil (1996) studied the effect of methanol spraying on yield and quality of groundnut and soybean. Her results indicated that foliar sprays of 20

per cent methanol at the critical growth stages increased their growth significantly.

### 2.1.2 Plant height

Ahmed *et al.* (1990) reported increase in seedlings height in triacontanol treated plants due to soaking of rice seeds in 0.01 to 1.0 ppm triacontanol for 1 hour. Srivastava and Sharma (1990) observed maximum plant height of opium poppy at 0.01 mg/lit triacontanol spray. Nonomura and Benson (1992) reported 15 per cent increase in height of cotton plant over control due to foliar application of 20 per cent methanol and increase in number of internodes of tomato from 9 (control) to 16 due to 3 foliar sprays of 20 per cent methanol.

Preharvest application of 4 ml per lit triacontrol increased the plant height of French bean (Chikkasubbanna *et al.*, 1995). Salunkhe (1995) pointed out that there was significant increase in height of safflower plants due to foliar spray of 20 per cent methanol. Similar results were obtained by Patil (1996) in case of groundnut and soybean. The plant heights at harvest were 36.7 cm for groundnut and 57 cm for soybean due to application of 20 per cent methanol while the control values were 34.6 and 36.7 cm, respectively.

Baruah <sup>*et al.*</sup> (1997) reported that foliar spray of Vipul in combination with zinc sulphate, urea and boric acid increased the height of tea plants. Salunkhe *et al.* (1998) reported that foliar application of methanol resulted in increase in plant height of wheat

branches per plant of green gram from 4.3 (control) to 8.3 (Adsul, 1999) and groundnut from 8.2 (control) to 9.8 (Ombase, 1999).

#### **2.1.4 Number of leaves per plant**

Kothale *et al.* (1993 a & b) reported that foliar application of 1000 ppm Mixtalol to groundnut significantly increased the number of leaves per plant. Baruah *et al.* (1997) reported that foliar application of Vipul in combination with zinc sulphate, urea and boric acid increased number of leaves per plant of tea.

The foliar spray of methanol increased number of leaves in green gram. The maximum number of leaves per plant (10.2) were obtained with three foliar sprays of 20 per cent methanol (with control value 5.2) (Adsul, 1999). Ombase (1999) reported that the foliar application of methanol increased the number of leaves per plant of groundnut. The maximum response (83.7) was obtained with three foliar sprays of 20 per cent methanol (with control value 60.8).

#### **2.1.5 Leaf area**

Erikson *et al.* (1981) reported increase in leaf area when tomato and maize plants were grown in a nutrient solution to which triacontanol was added twice per week. Nonomura and Benson (1992) studied the effect of methanol on growth and development of C<sub>3</sub> plants and reported that there was significant increase in size of cotton leaf due to foliar spray of 30 per cent methanol. Kothale *et al.* (1993 a & b) reported that foliar application of 100 ppm Mixtalol to groundnut significantly increased the leaf area.

Deotale *et al.* (1994a) observed that the foliar application of triacontanol increased the leaf area in groundnut with increasing concentration of triacontanol upto 50 ppm. Treated wheat foliage averaged more than 50 per cent greater in length and 35 per cent greater in width than blades of untreated control at 45 DAS due to 3 foliar applications of 20 per cent methanol (Nonomura and Benson, 1992). However, Albrecht *et al.* (1995) did not observe any significant difference in the leaf growth of winter wheat, spring wheat, spring barley and pea to several plant growth stages due to the foliar spray of 20 and 40 per cent methanol.

Leaf area of groundnut and soybean plants at 60 DAS increased from 13.9 dm<sup>2</sup> (for control) to 16.2 dm<sup>2</sup> and 13.5 to 20.8 dm<sup>2</sup>, respectively, with increase in the concentration of methanol upto 20 per cent (Patil, 1996). Baruah *et al.* (1997) reported that Vipul (triacontanol) sprayed in combination with zinc sulphate, urea and boric acid increased leaf area in tea plants.

The leaf area in green gram was significantly influenced by methanol spray. The highest leaf area i.e. 104 cm<sup>2</sup> was observed under three spray of 20 per cent methanol with control value 78.9 cm<sup>2</sup> (Adsul, 1999). Ombase (1999) reported highest leaf area i.e. 43 cm<sup>2</sup> under three applications of 20 per cent methanol with control value 34.2 cm<sup>2</sup>.

### **2.1.7 Leaf chlorophyll**

Srivastava and Sharma (1990) observed that total chlorophyll content of poppy leaves was maximum at 0.01 mg/lit of triacontanol concentration. Zhou *et al.* (1993) reported that foliar sprays of Mixtalol to rape significantly increased the leaf chlorophyll content.

Lal *et al.* (1996) reported that spray of 5 ppm Mixtalol enhanced chlorophyll content of leaves of coriander. Baruah *et al.* (1997) reported that foliar application of Vipul in combination with zinc sulphate, urea and boric acid significantly increased chlorophyll content of nursery tea plant leaves.

Adsul (1999) reported increase in leaf chlorophyll content of green gram from 100 mg/100 g (control) to 240 mg/100 g due to three foliar sprays of 20 per cent methanol. Similarly, increase in leaf chlorophyll content of groundnut from 208 mg/100 g (control) to 253 mg/100 g due to three foliar sprays of 20 per cent methanol was observed by Ombase (1999).

### **2.1.8 Number of days required for flowering**

Yee (1983) reported that when soybean plants were sprayed 3 times with 0.01 mg/Ft<sup>2</sup> triacontanol, flowered earlier than the control.

## **2.2 Dry matter accumulation**

Application of triacontanol has been reported to increase dry matter content in number of plants viz., rice (Ries and Wert, 1977;

Qian *et al.*, 1981; Devakumar *et al.*, 1986; Ahmed, 1990), groundnut (Kelaiya *et al.*, 1991; Kothale *et al.*, 1993b; Deotale *et al.*, 1994b), opium poppy (Srivastava and Sharma, 1990), cotton (Chen *et al.*, 1982) and chilli (Miniraj and Shanmugavelu, 1987).

Application of Mixtalol has also been found to increase the dry matter content of plants like rice, maize, tomato (Venkatramani *et al.*, 1987), *Brassica juncea* (Setia *et al.*, 1989).

The highest total dry matter accumulation in safflower plants was obtained with two foliar sprays of 20 per cent aqueous methanol (Salunkhe, 1995). Patil (1996) reported increase in dry matter content of groundnut and soybean with increase in concentration of methanol upto 20 per cent in foliar spray. Salunkhe *et al.* (1998) reported that the highest total matter accumulation in wheat i.e. 23.6 g/plant was obtained with two foliar sprays of 20 per cent aqueous methanol as compared control value of 21.3 g/plant.

## **2.3 Yield contributing characters**

### **2.3.1 Length of earhead**

The length of earhead of wheat has been reported to vary from 6.1 to 8.3 (Sarker and Torofdar, 1992). Ishwar Singh (1993) reported that two foliar sprays of Mixtalol significantly increased the ear length of barley by 2.17 per cent over control. Salunkhe *et al.* (1998) reported that the ear head length of wheat was not significantly influenced by the foliar sprays of methanol.

### 2.3.2 Thousand grain weight

The thousand grain weight of wheat has been reported to vary from 35.1 to 40 g (Rathi and Katyar, 1992; Sarker and Torofdar, 1992). Treatment of rice plants with 0.01 ppm triacontanol has been reported to increase the thousand grain weight of rice (Mahadevappa *et al.*, 1989; Kawashima *et al.*, 1989). At harvest, the culms of methanol treated wheat plants averaged twice the number of seeds and weight of the corresponding controls (Nonomura and Benson, 1992).

Ishwar Singh (1993) reported that foliar sprays of Mixtalol to barley significantly increased the thousand grain weight by 14.4 per cent over control.

The hundred grain weight of safflower seeds increased from 4.5 g to 5.2 g with increase in concentration of methanol from 0 to 20 per cent applied as foliar spray (Salunkhe, 1995). Patil (1996) reported that hundred kernel weights of groundnut and thousand seed weight of soybean were significantly increased from 27.7 g to 35.8 g and 115 g to 122 g, respectively with increase in concentration of methanol upto 20 per cent and decreased at higher level. Salunkhe *et al.* (1998) reported that foliar application of methanol did not have significant influence on the thousand seed weight of wheat.

Thousand seed weight of green gram was increased significantly from 32.2 g (control) to 39.3 g due to three foliar sprays of 20 per cent methanol (Adsul, 1999). Ombase (1999) observed that

the average seed weight of groundnut kernels were increased significantly with foliar sprays of methanol. The maximum weight of thousand seeds i.e. 865 g was observed by three foliar sprays of 20 per cent methanol with control value 780 g.

## **2.4 Yield**

### **2.4.1 Grain yield**

Increase in grain yield due to application of triacontanol has been reported in case of number of crop plants viz., maize (Ries *et al.*, 1978; Ohlrogee and Fulk-Bringman, 1980), tomato (Erikson *et al.*, 1981), rice (Jadhav *et al.*, 1984; Mahadevappa, 1989; Kawashima *et al.*, 1989), brinjal (Jyothi and Shanmugavelu, 1985), bean (Zheng *et al.*, 1986), chilli (Miniraj and Shanmugavelu, 1987), wheat (Jain *et al.*, 1988), groundnut (Deotale *et al.*, 1994b) and lentil (Setia *et al.*, 1995). Application of Mixtalol has also been reported to increase the grain yields of some crops like rice (Venkatramani *et al.*, 1987), groundnut (Kothale *et al.*, 1993b), barley (Ishwar Singh, 1993), *Brassica napus* (rape) (Zhou *et al.*, 1993, 1995).

Nonomura and Benson (1992) studied the effect of methanol spraying on the yield of several agricultural crops and reported the proportion of yield due to 3 foliar applications of 20 per cent methanol to that due to control as follows : tomato -65 : 41, strawberry -28:17 and egg plant 57 : 35. Water melon vines treated with methanol yielded 74 t/ha while in case of control, it was 54 t/ha i.e. 36 per cent increase in yield over control (Nonomura and Benson,

1992). However, Hartz *et al.* (1994) pointed that of methanol did not significantly influence fruit yields of tomato and water melon. The grain yield of safflower was increased from 13.8 to 16.9 q/ha with increase in the concentration of methanol applied as foliar spray, from 5 to 30 per cent (Salunkhe, 1995). Maximum yield was obtained with 20 per cent methanol. However, Albrecht *et al.* (1995) did not observed any significant difference, in the yield of winter wheat, spring wheat, spring barley and pea due to foliar sprays of 20 and 40 per cent methanol. Patil (1996) reported that the kernel yield of groundnut and grain yield of soybean were increased from 8.8 to 15.0 q/ha and 18.1 to 20.6 q/ha, respectively, with increase in the concentration of methanol from 5 to 20 per cent and decreased thereafter.

The grain yield of wheat was increased from 44.4 q/ha to 52.8 q/ha due to two foliar sprays of 20 per cent methanol (Salunkhe *et al.*, 1998).

The application of methanol significantly increased the grain yield of green gram. Three sprays of 20 per cent methanol gave the highest yields i.e. 27.9 q/ha with the control value 19.6 q/ha (Adsul, 1999). Ombase (1999) reported that the application of methanol significantly increased the kernel yield groundnut. The foliar application of three sprays of 20 per cent methanol at 30, 45 and 60 DAS gave about 40 per cent of kernel over the control.

## 2.4.2 Straw yield

Salunkhe (1995) reported that the straw yield of safflower increased significantly with increase in the concentration of methanol from 5 to 30 per cent. Maximum straw yield was obtained with 20 per cent methanol i.e. 51.5 q/ha as compared to 42.3 q/ha for control. Patil (1996) observed that haulm<sup>u</sup> yield of groundnut and straw yield of soybean were significantly increased from 16.8 to 25.3 q/ha and from 18.1 to 20.6 q/ha, respectively with increase in the concentration of methanol upto 20 per cent and decreased at higher levels. Salunkhe *et al.* (1998) reported that straw yield of wheat was increased significantly from 59.0 q/ha to 78.3 q/ha with two foliar applications of 20 per cent methanol.

## 2.5 Nutrient uptake by plants

Miniraj and Shanmugavelu (1987) applied triacontanol at 2 ppm at 30 days after transplanting of chilli and full bloom stage and observed that triacontanol treatment enhanced the N, P, K, Ca and Mg uptake. The Fe, Mn, Zn and Cu contents in shoots of opium poppy were maximum at 0.1 mg/lit triacontanol (Srivastava and Sharma, 1990).

Gaur and Bansal (1993) reported that treatments of Mixtalol caused increase in iron content in leaves and uptake of nitrogen in mustard.

The uptake of N, P and K by safflower plants was increased due to foliar spray of methanol (Salunkhe, 1995). The

highest N, P, K uptake was observed with 20 per cent methanol treatment. Patil (1996) reported that the uptake of N, P and K by groundnut and soybean plants increased with increase in concentration of methanol from 5 to 20 per cent and decreased at higher levels.

The N and P uptake by wheat plants was increased with increase in the concentration of methanol in foliar spray from 0 to 20 per cent and was decreased at higher concentrations. The K uptake was, however, not significantly influenced by the foliar sprays of methanol (Salunkhe *et al.*, 1998).

Adsul (1999) stated that N, P and K uptake by green gram plants was increased from 69.6 to 152.2, 9.1 to 18.1 and 43.1 to 65.5 q/ha, respectively due to three foliar sprays of 20 per cent methanol. Nitrogen, phosphorus and potassium uptake by groundnut plants was increased from 142.2 to 225.7, 27.1 to 49.9 and 64.8 to 95.8 q/ha, respectively due to three foliar sprays of 20 per cent methanol (Ombase, 1999).

## **2.6 Chemical composition of grain**

### **2.6.1 Moisture**

The moisture content of wheat shows a wide variation depending upon environmental, storage and processing conditions. Salunkhe (1995) reported highest moisture content in grains of wheat and safflower with foliar spray of 15 per cent and 30 per cent aqueous methanol, respectively. Moisture content of groundnut kernels was

not significantly increased with increase in the concentration of methanol from 0 to 30 per cent (Patil, 1996).

Adsul (1999) reported increase in moisture content of green gram grains from 9.9 per cent (control) to 10.8 per cent due to 3 foliar sprays of 20 per cent methanol. Increase in moisture content of groundnut kernels from 6.4 per cent (control) to 7.9 per cent due to 3 foliar sprays of 20 per cent methanol has been reported by Ombase (1999).

### **2.6.2 Carbohydrates**

Carbohydrates account for about 83 per cent of the total dry matter of wheat kernel (Salunkhe, 1995). Adsul (1999) stated that carbohydrate content in grains of green gram was decreased from 65 per cent (control) to 55.1 per cent due to 3 foliar sprays of 20 per cent methanol. Carbohydrate content in groundnut kernels was decreased from 19.8 per cent (control) to 12.2 per cent due to 3 foliar application of 20 per cent methanol (Ombase, 1999).

### **2.6.3 Protein**

The protein content of wheat grains varies from 9.61 to 15.83 per cent (Adsule *et al.*, 1985 a, b,c; Pharande *et al.*, 1988 a,b; Das *et al.*, 1990 and Nannor, 1992).

Ries and Wert (1971) reported that triacontanol treatment to rice plants caused increase in grain nitrogen content by 30 per cent over control. Mixtalol applied to *Brassica juncea* plants, as foliar spray, caused increase in protein content of the seed (Setia *et al.*, 1989).

Protein content of wheat grains and safflower seeds was increased from 12.2 to 13.9 percent from 16.4 to 18.6 per cent respectively, with increase in the concentration of methanol in the foliar spray from 5 to 20 per cent (Salunkhe, 1995). Patil (1996) reported that the protein content of groundnut and soybean seeds increased from 25.51 to 27.15 per cent and from 36.8 to 37.94 per cent, respectively with increase in the concentration of methanol in the foliar spray from 5 to 20 per cent and decreased at higher levels.

Adsul (1999) reported increase in protein content of green gram from 20.6 (control) to 29.3 per cent due to 3 foliar sprays of 20 per cent methanol. Increase in protein content of groundnut from 25.8 (control) to 29.2 per cent due to 3 foliar spray of 20 per cent methanol was reported by Ombase (1999).

#### **2.6.4 Fat**

Varietal differences in fat content of wheat grain from 0.92 to 2.75 per cent have been observed (Khan *et al.*, 1987; Das *et al.*, 1990; Punia *et al.*, 1992; Czuchajowska *et al.*, 1995).

Application of Mixtalol has been reported to increase the oil content of *Brassica jucea* (Setia *et al.*, 1989) and soybean seeds (Sharma *et al.*, 1989).

Salunkhe (1995) obtained maximum oil content in the safflower seeds due to 2 foliar sprays of 20 per cent methanol. The oil content of groundnut seeds was not increased significantly but in case of soybean increased significantly from 18 (control) to 18.5 per

cent due to 3 foliar sprays of 20 per cent methanol (Patil, 1996). Maximum fat content of grains of green gram i.e. 1.23 per cent was obtained due to 3 foliar sprays of 20 per cent methanol while control value was 1.13 % (Adsul, 1999). Ombase (1999) reported maximum fat content of kernels of groundnut i.e. 48.3 per cent due to 3 foliar sprays of 20 per cent methanol with control value 46.6 per cent.

### **2.6.5 Ash and minerals**

Wheat grain contains about 1.8 per cent of mineral matter or ash (McCane and Widdowson, 1953). Significant varietal differences in ash content of whole wheat flour, 1.14 to 1.92 per cent have been reported (Dhingra and Mehta, 1985; Singh and Paliwal, 1986; Das *et al.*, 1990; Sudhakar and Pandey, 1991).

The iron content in wheat grains, as reported by different workers, ranged from 0.50 to 5.86 mg/100 g (Czernine-Jewski *et al.*, 1964; Desai *et al.*, 1983; Peterson *et al.*, 1986; Iskander *et al.*, 1987; Khan *et al.*, 1987; Mandeep Kaur and Mehta, 1992).

Wheat grains contain 1.20 to 8.0 mg/100 g Mn and 1.4 to 10.0 mg/100 g Zn on dry basis (Adsule and Kadam, 1986). Ca content of wheat has been reported to be in the range of 22 to 98 mg/100 g on dry basis (Booth *et al.*, 1946).

Salunkhe (1995) studied the effect of foliar spray of methanol on wheat and safflower and reported that ash content of both crops was significantly increased from 1.63 to 2.16 per cent and from 1.46 to 1.93 per cent, respectively with increase in the

concentration of methanol upto 20 per cent and decreased at higher levels. Adsul (1999) reported that the ash content in green gram seeds was increased due to the foliar application of methanol and was maximum i.e. 3.53 per cent due to three foliar sprays of 20 per cent methanol at 25, 35 and 45 days after sowing. Ash and other mineral nutrients i.e. Ca, Fe and P in groundnut kernels were significantly increased over control in all methanol treatments (Ombase, 1999).

Increase in ash content may be the result of increased uptake of nutrients due to methanol treatment.

#### **2.6.6 Limiting amino acids**

Tryptophan content of wheat protein has been reported to vary from 0.70 to 1.90 g/16 g N (Barton and Moran, 1946; Dhingra and Mehta, 1985; Sosulski *et al.*, 1986; Khan *et al.*, 1987). Methionine content of wheat protein has been reported to vary from 0.80 to 1.32 g/16 g N (Barton and Moran, 1946; Austin and Ram, 1971; Dhingra and Mehta, 1985; Sosulski *et al.*, 1986; Khan *et al.*, 1987).

Three foliar sprays of 20 per cent methanol increased the methionine and tryptophan contents in green gram seed proteins by 67 per cent and 56 per cent, respectively; over the control (Adsul, 1999). Ombase (1999) reported increase in methionine and tryptophan content from 0.72 (control) to 0.92 g/100 g protein and from 0.71 (control) to 0.85 g/100 g protein, respectively, due to 3 foliar sprays of 20 per cent methanol.

## 2.7 Possible mechanism of action of methanol in C<sub>3</sub> plants

The study of path of carbon in photosynthesis revealed very rapid metabolism of (<sup>14</sup>C) methanol (Benson, 1951; Basham *et al.*, 1954; Quayle *et al.*, 1954). Methanol was utilised by *Chlorella* and *Scenedesmus* strains for sugar and amino acid production as fully and as rapidly as was carbon dioxide (Calvin and Benson, 1949). Subsequent studies revealed that plants metabolised methanol rapidly (Cossins, 1964).

Methanol is rapidly oxidised to formaldehyde (Fig. 1). Formaldehyde is condensed with pentose-5-phosphate to yield allulose-6-phosphate which epimerises to fructose-6-phosphate in bacteria (Cooney and Levine, 1972) fungi (Harder *et al.*, 1973).

• Methanol may be used as a source of fixed carbon or as a source of supplemental methyl groups for pectin production. The immediate response of plants to methanol treatment under direct sunlight was the visible perceptible increase in turgidity, generally indicative of opened stomata. Open stomata permit increased CO<sub>2</sub> assimilation, concomitantly the rate of transpiration is increased (Farqhar and Stanley, 1982). The high turgidity of field plants, soon after application of methanol, suggested rapid metabolism of carbon to sugar. The lack of response of C<sub>4</sub> plants to methanol indicates that photorespiration is required for metabolism of methanol.

According to Benson and Nonomura (1992) methanol treatment alters the relative reaction rates involved in  $\dot{C}O_2$  fixation and subsequent transformations in algae and leaves of  $C_3$  higher plants exposed to oxygen. The ratio of sucrose to glycolate is greatly increased by prior exposure to methanol. Though glycine and serine concentrations seem to be unchanged, the normal accumulation of glycolic acid when plants are exposed to oxygen is inhibited. The process must involve intracellular formaldehyde production and consequent alteration of enzyme conformation and rates. The observed enhancement of productivity is consistent with apparent inhibition of photo-respiration of formaldehyde produced at specific sites within the plant cell.

Idso *et al.* (1995), however, did not observe any unambiguous effects of foliar sprays of 40 per cent methanol in terms of net photosynthesis rate on sunlit leaves of sour orange.

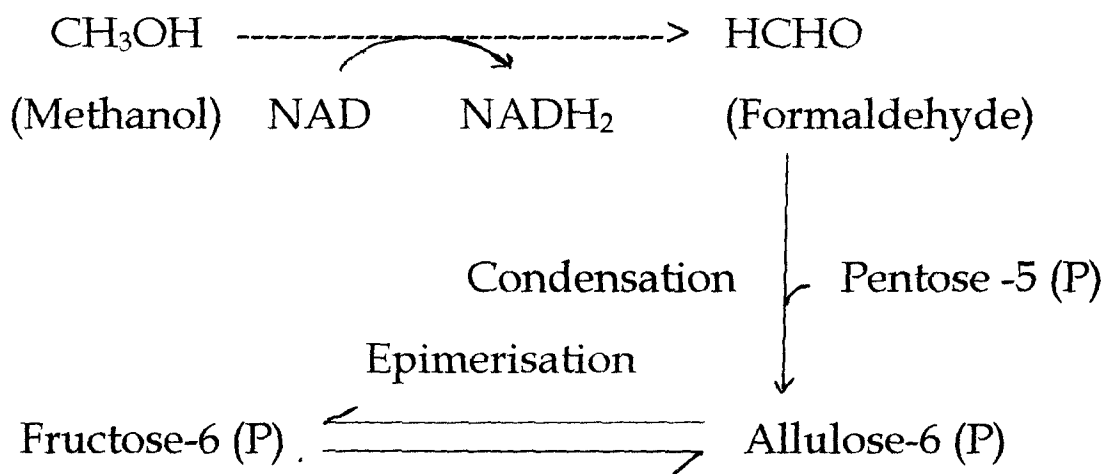


Fig. 1. Possible pathway of metabolism of methanol in plants (Ref. Nonomura and Benson, 1992)

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**MATERIAL AND METHODS**

physical and chemical properties of these soil samples were determined in triplicate sets and the mean values are shown in Table 1.

Table 1. Physico-chemical characteristics of soil from experimental plot

Sr. No.	Characteristic/constituent	Content
1.	Sand (%)	20.5
2.	Silt (%)	16.2
3.	Clay (%)	59.1
4.	Textural class	Clay
5.	pH	8.22
6.	EC (dS <sup>-1</sup> )	0.37
7.	Organic carbon (%)	0.47
8.	CaCO <sub>3</sub> (%)	9.5
9.	Available N (kg/ha)	158.0
10.	Available P (kg/ha)	13.0
11.	Available K (kg/ha)	249.0

The soil was calcareous, alkaline in pH, medium in organic carbon and low in available N, medium in available P and high in available K.

### 3.1.3 Climatic conditions

The Central Campus Farm of the Mahatma Phule Krishi Vidyapeeth, Rahuri is situated between 19°47' and 19°57' North

latitude and between  $74^{\circ}37'$  and  $74^{\circ}19'$  east longitude. The elevation of the area above mean sea level varies from 495 to 569 meters. The area falls in semi-arid tropics with annual rainfall varying from 307 to 619 mm, the average being about 520 mm, distributed over 15 to 45 days in different years. Out of total rainfall, about 80 per cent is received from south west monsoon from June to September, while the rest is received in October and November. The annual mean maximum and minimum temperatures are  $38^{\circ}\text{C}$  and  $17^{\circ}\text{C}$  which range from  $33^{\circ}\text{C}$  to  $43^{\circ}\text{C}$  and  $3^{\circ}\text{C}$  to  $18^{\circ}\text{C}$ , respectively. The mean relative humidity varies from 39 to 59 per cent.

#### **3.1.4 Seeds**

Pure seeds of wheat (cv. HD-2189) were obtained from the Chief Seeds Officer, Mahatma Phule Krishi Vidyapeeth, Rahuri.

#### **3.1.5 Fertilizers**

The nitrogen, phosphorus and potassium fertilizers were applied in the form of urea (46 % N), single super phosphate (16 %  $\text{P}_2\text{O}_5$ ) and muriate of potash (60 %  $\text{K}_2\text{O}$ ) which were obtained from the local market.

#### **3.1.6 Chemicals**

All the chemicals used for analysis of soil and plant samples were of analytical (A.R.) grade. They were obtained from M/s. Qualigens Fine Chemicals, Mumbai, S.D. Fine Chemicals, Mumbai, E. Merck, Mumbai, Sarabhai M. Chemicals, Baroda and Sisco Research Laboratories, Mumbai. Methanol used in the present

study was kindly supplied by the Rashtriya Chemicals and Fertilizers (RCF), Mumbai.

### **3.1.7 Glassware**

The glassware used for analytical work were of Borosil, Pyrex, Corning (India) and Solar makes.

### **3.1.8 Sprayer**

A hand rotatory sprayer of 15 litre capacity of Aspee make was used for spraying methanol.

## **3.2 Methods**

### **3.2.1 Land preparation**

The experiment was laid out on well levelled plot in medium black soil with uniform fertility. The land was prepared by ploughing and harrowing twice.

### **3.2.2 Layout of experiment**

The field experiment was laid out in a Factorial Randomised Block Design (F.R.B.D.), as detailed in Fig. 2. Other details of the experiment are as follows.

- A. Crop and variety : Wheat : HD-2189
- B. Design : Factorial Randomised Block Design
- C. Number of replications : 2
- D. Number of treatments : 16
- E. Number of plots : 32

- F. Plot size
- Gross : 4.05 x 4.50 m  
(18.225 m<sup>2</sup>)
- Net : 3.15 x 3.70 m  
(11.65 m<sup>2</sup>)
- G. Spacing : 22.5 x 10 cm
- H. Date of sowing : 5.12.1996
- I. Method of sowing : Dibbling
- J. Methanol concentrations (Factor A)
- C<sub>1</sub> : Control (0 % methanol)
- C<sub>2</sub> : 10 % methanol
- C<sub>3</sub> : 20 % methanol
- C<sub>4</sub> : 30 % methanol
- K. Time of application (Factor B)
- I<sub>1</sub> : 30 DAS
- I<sub>2</sub> : 30 + 45 DAS
- I<sub>3</sub> : 45 + 60 DAS
- I<sub>4</sub> : 30 + 45 + 60 DAS

Aqueous solutions with varying concentrations of methanol as per the treatments (0, 10, 20, 30 per cent) with 0.1 per cent surfactant were prepared just before use and used as foliar spray at 30, 45 and 60 DAS as per the treatment combinations.

Fig. 2. Layout of field experiment

### 3.2.3 Fertilizer application

The fertilizers were applied as per the recommended dose of 120 kg N, 60 kg P<sub>2</sub>O<sub>5</sub> and 60 kg K<sub>2</sub>O/ha. Half the dose of nitrogen and full dose of phosphorus and potassium were applied at the time of sowing, the remaining dose of nitrogen was applied at 21 days after sowing as top dressing.

### 3.2.4 Seed treatment

The seeds of wheat were treated with thiram @ 3g/kg seed as per the recommended practice to control fungal diseases.

### 3.2.5 Sowing

The sowing of seeds was done on 5th December, 1996 dibbling two seeds per hill at a spacing of 22.5 cm between the rows and 10 cm within the row.

### 3.2.6 Stages of foliar spray

The foliar sprays of methanol were given at noon time on bright sunny days. The quantity of methanol sprayed was sufficient to cover the entire foliage at following growth stages.

- a. 30 DAS
- b. 30 + 45 DAS
- c. 45 + 60 DAS
- d. 30 + 45 + 60 DAS

The actual dates of spraying were as follows.

First foliar spray	:	4th January, 1997
Second foliar spray	:	19th January, 1997

Third foliar spray : 3rd February, 1997

The actual quantities of undiluted methanol required per plot at each spray were as follows.

Table 2. Quantity of methanol (ml/plot) required for each treatment

Sr. No.	Treatment	30 DAS (4.1.1997)	45 DAS (19.1.1997)	60 DAS (3.2.1997)	Total
1.	C <sub>1</sub> I <sub>1</sub>	-	-	-	-
2.	C <sub>1</sub> I <sub>2</sub>	-	-	-	-
3.	C <sub>1</sub> I <sub>3</sub>	-	-	-	-
4.	C <sub>1</sub> I <sub>4</sub>	-	-	-	-
5.	C <sub>2</sub> I <sub>1</sub>	30	-	-	30
6.	C <sub>2</sub> I <sub>2</sub>	30	40	-	70
7.	C <sub>2</sub> I <sub>3</sub>	-	40	50	90
8.	C <sub>2</sub> I <sub>4</sub>	30	40	50	120
9.	C <sub>3</sub> I <sub>1</sub>	60	-	-	60
10.	C <sub>3</sub> I <sub>2</sub>	60	80	-	140
11.	C <sub>3</sub> I <sub>3</sub>	-	80	100	180
12.	C <sub>3</sub> I <sub>4</sub>	60	80	100	240
13.	C <sub>4</sub> I <sub>1</sub>	90	-	-	90
14.	C <sub>4</sub> I <sub>2</sub>	90	120	-	210
15.	C <sub>4</sub> I <sub>3</sub>	-	120	150	270
16.	C <sub>4</sub> I <sub>4</sub>	90	120	150	360
	<b>Total</b>	<b>540</b>	<b>720</b>	<b>600</b>	<b>1860</b>

### **3.2.7 Irrigations**

The first irrigation was given to wheat crop immediately after sowing. The second and subsequent irrigations were given as detailed below.

Irrigation No.	DAS
2	21
3	41
4	70
5	90

### **3.2.8 Cultural practices**

The recommended cultural practices for wheat cultivation viz., thinning, gap filling, weeding and plant protection measures were carried out during the growth period. Spraying of Dithane M-45 was given after 65 DAS for protection of crop from rust.

### **3.2.9 Growth observations**

In each net plot three plants were selected randomly and labelled for recording of observations. The number of leaves and number of tillers were recorded at 65 DAS leaf area at 65 DAS was determined by using leaf area meter (LI-COR). The height of the plants was recorded from ground level to the base of last fully opened top leaf. The chlorophyll content was determined by extraction with acetone absorbance, at 65 DAS.

Table 3. Schedule of cultural and other operations carried out during rabi 1996-97

Sr. No.	Name of the operation	Frequency	Date
1.	Ploughing	1	08.10.1996
2.	Harrowing	1	25.10.1996
3.	Stubble collection	1	20.11.1996
4.	Layout of experiment	1	28.11.1996
5.	Preparation of plots	1	30.11.1996
6.	Fertilizer application	1	05.12.1996
7.	Sowing	1	05.12.1996
8.	Gap filling	1	15.12.1996
9.	Thinning	1	15.12.1996
10.	Hand weeding	2	22.12.1996, 6.01.1997
11.	Irrigations	5	
	a. First		05.12.1996
	b. Second		26.12.1996
	c. Third		15.01.1997
	d. Fourth		13.02.1997
	e. Fifth		05.03.1997
12.	Foliar sprays of methanol	3	
	a. First		04.01.1997
	b. Second		19.01.1997
	c. Third		03.02.1997
13.	Harvesting		10.04.1997
14.	Threshing and cleaning	1	16.04.1997

### **3.2.10 Dry matter studies**

The plant samples were collected at harvest i.e. on 10.4.1997. For this, three well spaced plants were randomly selected from each net plot. The plant parts were separated and dried in hot air oven at 70°C for first two hours and then at 60°C till the samples were completely dried. The dry matter of individual plant parts was recorded separately and then total dry matter weight per plant was computed.

### **3.2.11 Yield contributing characters**

#### **3.2.11.1 Number of earheads/plant**

The number of earheads on the plant were counted from the observation plants just before harvesting and the average value were recorded.

#### **3.2.11.2 Length of earheads**

The length of the earheads from the observation plants from each plant was measured and mean values were recorded.

#### **3.2.11.3 Thousand grain weight**

The harvested wheat plants from each plot were threshed separately. One thousand seeds were counted and weighed in triplicate sets and mean values were recorded.

### **3.2.12 Yield studies**

#### **3.2.12.1 Grain and straw yields**

All the plants were harvested from each net plot and their weights were recorded. They were threshed and the seeds were

collected. The grain yields were recorded separately. From this, grain yield per hectare was worked out. The straw yield per plot was calculated by deducting the weights of grain per plot from the total plant weight per plot. From this, the straw yield per hectare was calculated.

### **3.2.13 Physico-chemical analysis of soil**

The soil samples collected before sowing were analysed for physico-chemical characteristics by adopting standard methods of analysis as given in Table 3.

### **3.2.14 Analysis of plants and seeds**

#### **3.2.14.1 Total chlorophyll**

For the determination of chlorophyll content, the samples of mature leaf (3rd leaf) were taken from the randomly selected three plants of each plot. The leaves were brought to the laboratory in ice bucket. These were washed with distilled water and two hundred mg of fresh leaf was chopped into fine pieces and taken into 25 ml volumetric flask. The volume was made up with 80 per cent acetone. The content was shaken intermittently and kept in dark for 24 hours. After complete extraction the colour intensity was measured on Spectronic-20 at 652 nm (Arnon, 1949) and total chlorophyll was computed by using simultaneous equations of Brouers and Michael-Wolwertz (1983).

### **3.2.14.2 Analysis of shoot dry matter**

The samples of shoot portion of wheat plants (15 plants) were selected randomly from the each net plot and were drawn at harvesting stage. About 20 g of oven dried sample was ground in Willey grinding mill to powder about 40 mesh size. The dry powder of the samples was preserved in plastic air tight containers until used for estimation. These samples were used to determine the plant N,P,K composition by adopting standard methods.

#### **3.2.14.2.1 Total nitrogen**

Acid extract was prepared of 0.2 g plant sample by digestion with 30 per cent  $\text{H}_2\text{O}_2$  and  $\text{H}_2\text{SO}_4$  (Conc.) mixture (Parkinson and Allen, 1975). The volume of digested material was made to 50 ml with distilled water after cooling. The distillation was carried out with taking 5 ml extract by micro kjeldahl's method (A.O.A.C., 1980).

#### **3.2.14.2.2 Phosphorus**

The plant dry matter extract prepared for estimation of total nitrogen (acid extract) was used for phosphorus estimation . The phosphorus content was determined by colorimetric method (Chapman and Pratt, 1961).

#### **3.2.14.2.3 Potassium**

The acid extract ( $\text{H}_2\text{O}_2$  and  $\text{H}_2\text{SO}_4$ ) was filtered, diluted (1 ml to 50 ml) with distilled water and used for potassium

determination with the help of flame photometer as described by Chapman and Pratt (1961).

Nitrogen, phosphorus and potassium uptake was calculated by using total dry matter weight of plants and N, P, K content (%) of plants; with help of the formula :

$$\text{NPK uptake by plants/ha} = \frac{\text{Dry matter weight per plant} \times \text{Plant population/ha} \times \text{N/P/K content (\%)}}{100}$$

### 3.2.14.3 Analysis of wheat grains

Wheat grain samples from each treatment plot were powdered in Willey grinding mill to pass through 40 mesh sieve. The contents of moisture, carbohydrate, crude protein, fat, ash, calcium, iron, phosphorus tryptophan and methionine were determined according to standard procedures as given in Table 4. The crude protein content was calculated by multiplying nitrogen content by a factor of 5.7.

The analysis of samples was done in triplicate sets and mean values have been reported. The data obtained were subjected to statistical analysis according to the procedure given by Panse and Sukhatme (1967).

Table 4. Analytical methods used for soil, plant and grain analysis

Sr. No.	Property	Method adopted	Reference
<b>A.</b>	<b>Soil analysis</b>		
1.	pH (1:2.5)	Potentiometric	Jackson (1973)
2.	Electrical conductivity	Conductometric	Jackson (1973)
3.	Organic carbon	Rapid titration	Walkley and Black (1956)
4.	Available nitrogen	Modified alkaline permanganate	Subbiah and Asija (1956)
5.	Available phosphorus	0.5 M NaHCO <sub>3</sub> pH 8.5 (Colorimetric)	Olsen <i>et al.</i> (1954)
6.	Available potassium	Neutral normal ammonium acetate	Page <i>et al.</i> (1982)
7.	Calcium carbonate equivalent	Rapid titration	Black (1965)
<b>B.</b>	<b>Plant and grain analysis</b>		
1.	Nitrogen	Microkjeldahl	A.O.A.C (1975)
2.	Phosphorus	Colorimetric	Chapman and Pratt (1961)
3.	Potassium	Flame photometer	Chapman and Pratt (1961)
4.	Moisture	Gravimetric	A.O.A.C. (1975)
5.	Carbohydrate	By difference	A.O.A.C (1975)
6.	Protein	Microkjeldahl	A O A C (1975)
7.	Crude fat	Soxhlet extraction	A.O.A.C. (1975)
8.	Ash	Dry ashing	A.O.A.C. (1975)
9.	Calcium	Versanate method	Black <i>et al.</i> (1965)
10.	Iron	Atomic absorption	Parkinson <sup>*</sup> and Allen (1975)
11.	Methionine	Colorimetric	McCarthy and Pellie (1959)
12.	Tryptophan	Colorimetric	Spice and Chambers (1949)

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**RESULTS AND DISCUSSION**

## 4. RESULTS AND DISCUSSION

The present investigation was undertaken during the *rabi* season of 1996-97 to study the influence of concentration and time of foliar application of methanol on growth, yield and quality of wheat. The effect of methanol on the plant height, number of tillers, number of leaves, leaf area, leaf chlorophyll, length of earheads, dry matter accumulation, NPK content and uptake, moisture, carbohydrates, proteins, fats, minerals, tryptophan, calcium, phosphorus, iron and methionine contents in the wheat grain was studied. The data thus collected have been presented and discussed in this chapter under appropriate subheadings.

### 4.1 Preharvest studies

#### 4.1.1 Plant height

The data on the height of wheat plants as influenced by the concentration and time of application of methanol are given in Table 5. It was observed that the height of wheat plants increased with increase in the concentration of methanol upto 20 per cent and decreased at 30 per cent. Treatment C<sub>3</sub> (20 % methanol) was significantly superior to rest of the treatments. The maximum height was obtained by three foliar sprays of methanol at 30 + 45 + 60 DAS (I<sub>4</sub>) which was at par with two early sprays of methanol at 30 + 45 DAS (I<sub>2</sub>) but was significantly superior over two late sprays of methanol at 45 + 60 DAS (I<sub>3</sub>) and one foliar spray of methanol at 30

Table 5. Effect of levels and number of foliar sprays of methanol on the height (cm) of wheat plant

Concentration of methanol (%)	Interval of application (DAS)				Mean
	30 (I <sub>1</sub> )	30 + 45 (I <sub>2</sub> )	45 + 60 (I <sub>3</sub> )	30 + 45 + 60 (I <sub>4</sub> )	
0 (C <sub>1</sub> )	90	92	91	92	91.3
10 (C <sub>2</sub> )	97	103	100	106	101.5
20 (C <sub>3</sub> )	102	110	106	105	108.3
30 (C <sub>4</sub> )	98	106	104	108	104.0
Mean	96.8	102.8	100.3	105.3	
	Factor A	Factor B	Interaction (A x B)		
S.E. <sub>±</sub>	0.8	0.8	0.16		
CD at 5 %	2.5	2.5	N.S.		

N.S. = Non-significant

DAS ( $I_1$ ). Two foliar sprays at early growth stages at 30 + 45 DAS ( $I_2$ ) two foliar sprays at later growth stages at 45 + 60 DAS ( $I_3$ ) were at par and significantly superior over one spray at 30 DAS ( $I_1$ ). Among the treatment combinations, the highest plant height was obtained due to three foliar sprays of 20 per cent methanol at 30, 45 and 60 DAS ( $C_3I_4$ ) which was higher than the control ( $C_1I_1$ ) by about 28 per cent.

The results are in conformity with those of Salunkhe (1995) who reported maximum height of 112 cm for wheat plants due to two foliar applications of 20 per cent methanol while the control value was 102 cm. The heights of groundnut and soybean plants were increased with increase in the concentration of methanol upto 20 per cent and declined at higher concentrations (Patil, 1996).

Adsul (1999) reported that the height of green gram plants was increased from 28.1 cm for control to 36.1 cm for 3 foliar sprays of 20 per cent methanol. The increase in concentration of methanol increased the height of groundnut plants from 20.6 cm for control to 24.1 cm for 3 foliar sprays of 20 per cent methanol (Ombase, 1999).

#### **4.1.2 Number of tillers/plant**

It was observed that the number of tillers per plant were significantly increased with increase in concentration of methanol upto 20 per cent ( $C_3$ ) and decreased at 30 per cent concentration (Table 6, Fig. 3). The treatment  $C_3$  was significantly superior to rest of the treatments. The treatment  $C_4$  was at par with treatment  $C_2$ .

Table 6. Effect of levels and number of foliar sprays of methanol on number of tillers/plant of wheat

Concentration of methanol (%)	Interval of application (DAS)				Mean
	30 (I <sub>1</sub> )	30 + 45 (I <sub>2</sub> )	45 + 60 (I <sub>3</sub> )	30 + 45 + 60 (I <sub>4</sub> )	
0 (C <sub>1</sub> )	5.8	5.8	5.8	5.9	5.8
10 (C <sub>2</sub> )	6.1	7.2	8.0	8.1	7.4
20 (C <sub>3</sub> )	7.2	7.6	8.5	8.6	8.0
30 (C <sub>4</sub> )	6.2	7.3	8.1	8.3	7.5
Mean	6.3	7.0	7.6	7.7	
	Factor A	Factor B	Interaction (A x B)		
S.E. <sub>±</sub>	0.09	0.09	0.18		
CD at 5 %	0.28	0.28	0.56		

Fig. 3. Effect of levels and number of foliar sprays of methanol on number of tillers/plant of wheat

The number of tillers per plant were significantly increased with increase in the number of foliar sprays of methanol from 1 to 3. The treatments I<sub>3</sub> and I<sub>4</sub> were at par with each other but significantly superior to I<sub>1</sub> and I<sub>2</sub>. Among the treatment combinations, the maximum number of tillers per plant of wheat were obtained due to application of 20 per cent methanol at 30, 45 and 60 DAS (C<sub>3</sub>I<sub>4</sub>) which were higher than control (C<sub>1</sub>I<sub>1</sub>) by about 48 per cent. The interaction effects were found to be significant.

Salunkhe (1995) observed that maximum number of 11.6 tillers per plant in wheat by spraying 20 per cent methanol as compared to 8.8 per cent for control. Patil (1996) found that foliar application of 20 per cent methanol increased the mean number of branches/plant of groundnut and soybean.

Adsul (1999) reported that increase in concentration of foliar sprays of methanol increased number of branches per plant of green gram from 4.33 for control to 8.33 for 3 foliar sprays of 20 per cent methanol. The increase in the concentration of foliar spray of methanol increased number of branches per plant of groundnut from 8.2 for control to 9.8 for 3 foliar sprays of 20 per cent methanol and decreased thereafter (Ombase, 1999).

#### **4.1.3 Number of leaves/plant**

The data on number of leaves/plant of wheat plants as affected by the concentration and time of application of methanol are presented in Table 7 and Fig. 4. The number of leaves/plant

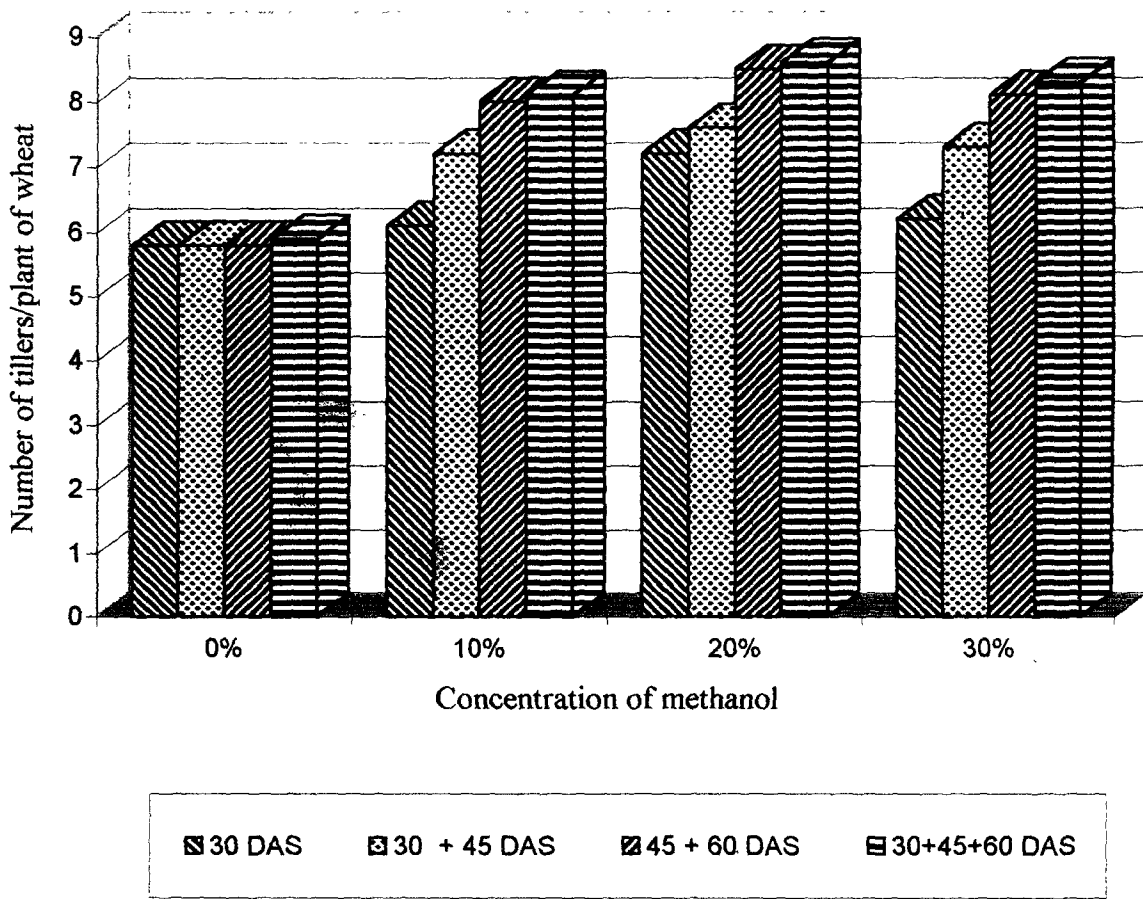


Fig. 3. Effect of levels and number of foliar sprays of methanol on number of tillers/plant of wheat

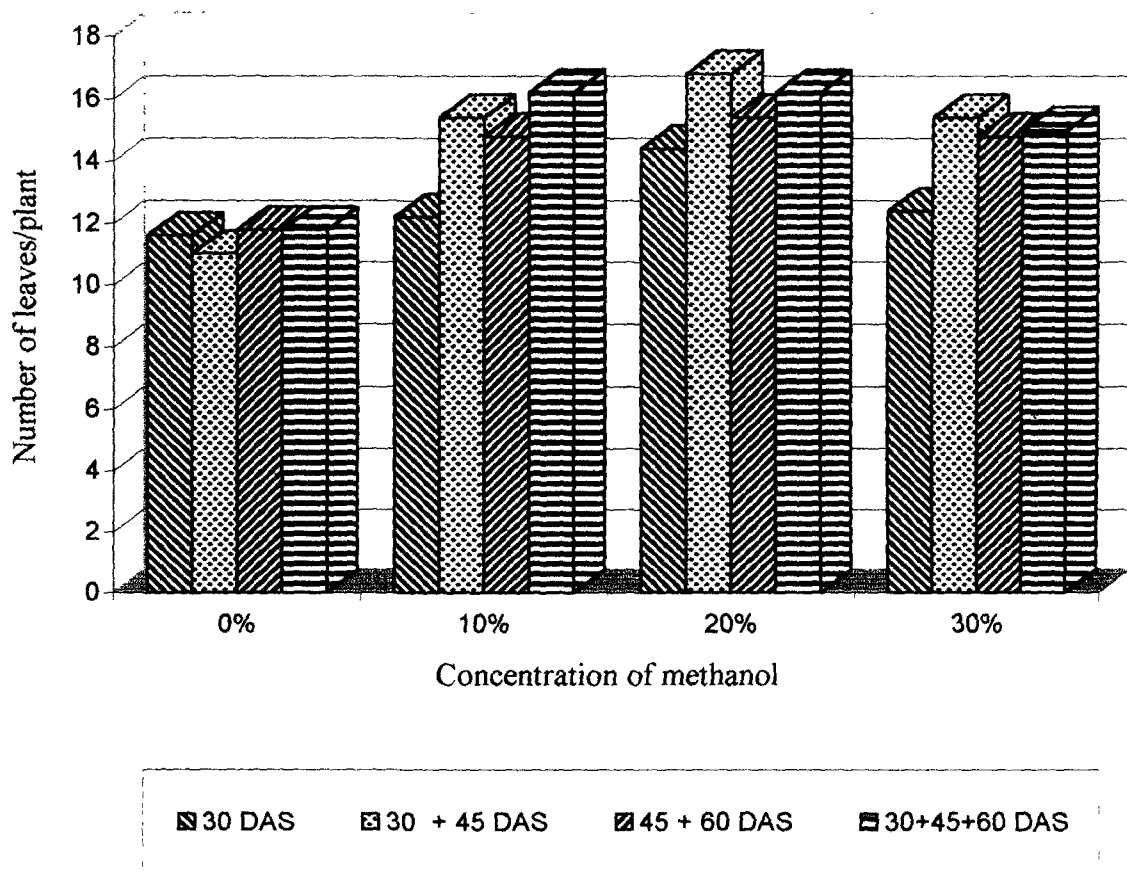


Fig. 4. Effect of levels and number of foliar sprays of methanol on number of leaves/plant

increased with increase in the concentration of methanol upto 20 per cent (C<sub>3</sub>) and decreased at 30 per cent. The treatment C<sub>3</sub> (20 % methanol) was significantly superior to rest of the treatments while C<sub>2</sub> and C<sub>4</sub> were at par with each other but significantly superior over control.

The increase in the number of sprays of methanol significantly increased the number of leaves per plant. The highest number of leaves/plant were observed by three sprays of methanol (I<sub>4</sub>) which was significantly superior to I<sub>1</sub> and I<sub>3</sub> treatments. The treatments I<sub>2</sub> and I<sub>3</sub> were at par with each other but were significantly superior over control (I<sub>1</sub>). Among the treatment combinations, the maximum number of leaves per plant of wheat were obtained due to three foliar sprays of 20 per cent methanol at 30, 45 and 60 DAS (C<sub>3</sub>I<sub>4</sub>). The interaction effects were found to be significant.

Kothale et al. (1993 a & b) reported that the number of leaves per plant of groundnut was increased significantly with increasing levels of Mixtalol from 15 to 100 ppm Baruah et al. (1997) observed that foliar application of Vipul increased the number of leaves/plant.

Increase in concentration of foliar spray of methanol increased the number of leaves of green gram from 5.2 for control to 10.2 for 3 foliar sprays of 20 per cent methanol (Adsul, 1999). Ombase (1999) reported that increase in concentration of foliar spray of

methanol increased the number of leaves of groundnut from 60.8 for control to 83.7 for 3 foliar sprays of 20 per cent methanol.

#### **4.1.4 Leaf area**

The leaf area of wheat plants was significantly increased due to the foliar application of methanol (Table 8 and Fig. 5). The maximum leaf area of wheat plant was recorded under treatment C<sub>3</sub> which was significantly superior over rest of the treatments. Treatments C<sub>2</sub> and C<sub>4</sub> were at par with each other.

The highest leaf area per plant was observed by three sprays of methanol (I<sub>4</sub>) which was significantly superior to one (I<sub>1</sub>) and two (I<sub>2</sub>, I<sub>3</sub>) sprays. The treatment I<sub>2</sub> was at par with I<sub>3</sub>. Among the treatment combinations, the maximum leaf area of wheat plant was obtained due to three application of 20 per cent methanol at 30, 45 and 60 DAS (C<sub>3</sub>I<sub>4</sub>). The interaction effects were found to be non-significant.

Nonomura and Benson (1992) showed significant increase in leaf size of cotton plants due to foliar spray of 30 per cent methanol. The area of groundnut and soybean plants was increased with increase in concentration of methanol upto 20 per cent and declined thereafter (Patil, 1996).

Adsul (1999) reported that increase in concentration of foliar spray of methanol increased the leaf area of greengram from 78.9 cm<sup>2</sup> for control to 104.2 cm<sup>2</sup> for 3 foliar sprays of 20 per cent methanol. Increase in concentration of foliar spray of methanol

Table 8. Effect of levels and number of foliar sprays of methanol on leaf area (cm<sup>2</sup>) of wheat

Concentration of methanol (%)	Interval of application (DAS)				Mean
	30 (I <sub>1</sub> )	30 + 45 (I <sub>2</sub> )	45 + 60 (I <sub>3</sub> )	30 + 45 + 60 (I <sub>4</sub> )	
0 (C <sub>1</sub> )	18.5	19.0	18.5	19.0	18.75
10 (C <sub>2</sub> )	21.2	22.8	22.2	24.8	22.75
20 (C <sub>3</sub> )	23.8	26.2	24.8	27.2	25.50
30 (C <sub>4</sub> )	22.0	23.5	22.5	26.5	23.63
Mean	21.38	22.88	22.0	24.38	
	Factor A	Factor B	Interaction (A x B)		
S.E. <sub>±</sub>	0.37	0.37	0.74		
CD at 5 %	1.13	1.13	2.26		

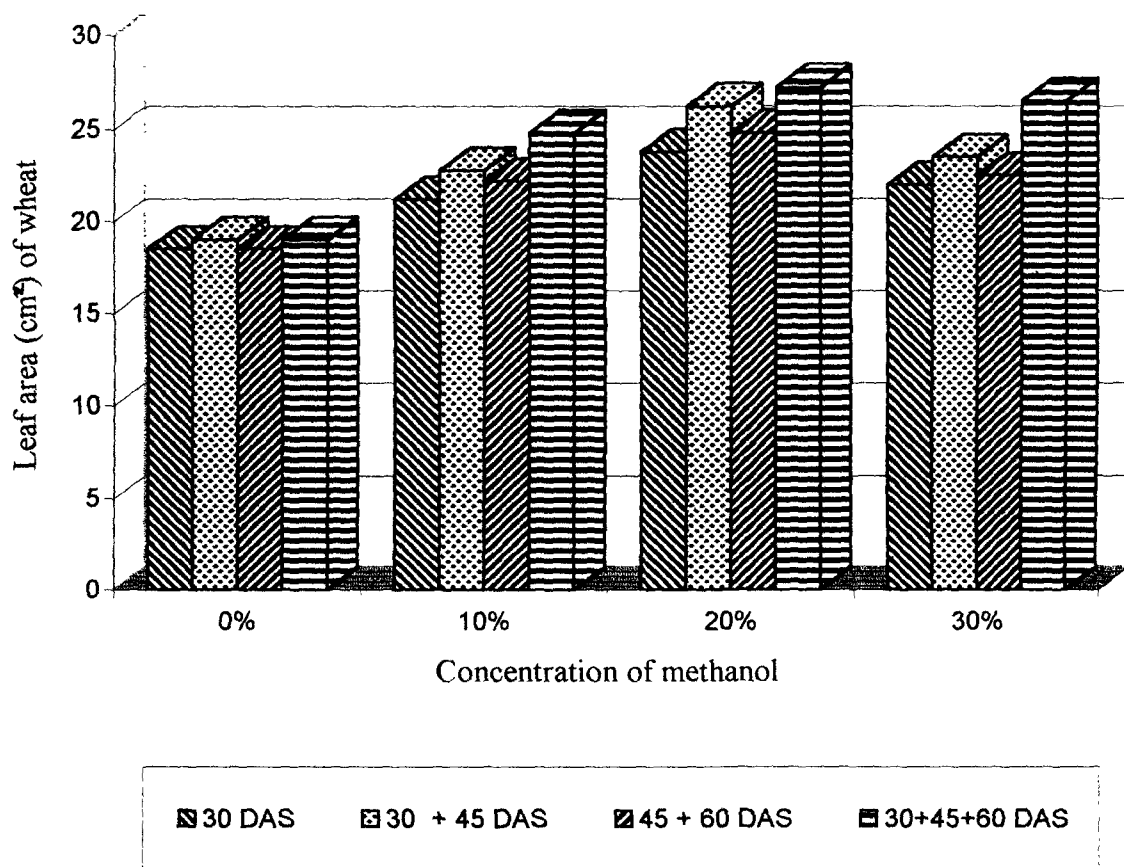


Fig. 5. Effect of levels and number of foliar sprays of methanol on leaf area ( $\text{cm}^2$ ) of wheat

increased the leaf area of groundnut from 34.2 cm<sup>2</sup> for control to 43 cm<sup>2</sup> for 3 foliar sprays of 20 per cent methanol at 30, 45 and 60 DAS (Ombase, 1999).

#### **4.1.5 Chlorophyll**

The chlorophyll content of wheat leaves was significantly increased due to foliar application of methanol (Table 9). The chlorophyll content of leaves was significantly increased with increase in the concentration of methanol upto 20 per cent (C<sub>3</sub>) and decreased at 30 per cent. The treatment C<sub>3</sub> was significantly superior to rest of the treatments. Treatments C<sub>2</sub> and C<sub>4</sub> were at par with each other.

The maximum chlorophyll content was observed due to three foliar sprays of methanol (I<sub>4</sub>) which was significantly superior to rest of the treatments. The treatments I<sub>2</sub> and I<sub>3</sub> were at par with each other but significantly superior to I<sub>1</sub>. Among the treatment combinations, the maximum chlorophyll content of wheat leaves was obtained due to application of 20 per cent methanol at 30, 45 and 60 DAS (C<sub>3</sub>I<sub>4</sub>) which was higher than control (C<sub>1</sub>I<sub>1</sub>) by about 23 per cent. The interaction effects were found to be non-significant.

Earlier workers have reported increase in leaf chlorophyll content due to application of photosynthesis improvers viz. Mixtalol in case of rape (Zhou et al., 1993) and Vipul in case of tea (Baruah et al., 1997).

Table 9. Effect of levels and number of foliar sprays of methanol on chlorophyll content (mg/100 g) in wheat leaves

Concentration of methanol (%)	Interval of application (DAS)				Mean
	30 (I <sub>1</sub> )	30 + 45 (I <sub>2</sub> )	45 + 60 (I <sub>3</sub> )	30 + 45 + 60 (I <sub>4</sub> )	
0 (C <sub>1</sub> )	75.0	73.0	74.5	74.0	74.13
10 (C <sub>2</sub> )	77.5	82.0	80.5	83.0	80.75
20 (C <sub>3</sub> )	80.0	88.0	86.0	92.0	86.50
30 (C <sub>4</sub> )	78.8	82.5	80.0	85.0	81.58
Mean	77.83	81.38	80.25	83.50	
	Factor A	Factor B	Interaction (A x B)		
S.E. <sub>±</sub>	0.67	0.67	1.34		
CD at 5 %	2.01	2.01	N.S.		

N.S. = Non-significant

Increase in concentration of methanol used as foliar spray, increased the chlorophyll content of leaves of green gram from 100 mg/100 g for control to 240 mg/100 g for 3 foliar sprays of 20 per cent methanol 25, 35 and 45 DAS (Adsul, 1999). Ombase (1999) reported that increase in concentration of foliar spray of methanol increased the chlorophyll content of leaves of groundnut from 208 mg/100 g for control to 253 mg/100 g for 3 foliar sprays of 20 per cent methanol at 30, 45 and 60 DAS.

## **4.2 Post harvest studies**

### **4.2.1 Length of earheads**

With increase in the concentration and the number of foliar sprays of methanol, there was increase in the length of earheads (Table 10). The length of earheads was highest under treatment C<sub>3</sub> followed by treatments C<sub>4</sub>, C<sub>2</sub> and C<sub>1</sub>. Treatment C<sub>4</sub> was at par with C<sub>3</sub> and C<sub>2</sub>. The treatment I<sub>2</sub> was at par with I<sub>3</sub> and I<sub>4</sub> while I<sub>3</sub> was at par with I<sub>1</sub>. Among the treatment combinations, the maximum length of earheads was obtained due to three foliar sprays of 20 per cent methanol at 30, 45 and 60 DAS (C<sub>3</sub>I<sub>4</sub>) which was higher than C<sub>1</sub>I<sub>1</sub> by about 17 per cent. The interaction effects were found to be non-significant.

The above findings are in conformity with those of Ishwar Singh (1993) who reported that the two foliar sprays of Mixtalol significantly increased the earlength of barley over the control. Salunkhe (1995) reported increase in the earlength of wheat

Table 10. Effect of levels and number of foliar sprays of methanol on length of earhead (cm) of wheat

Concentration of methanol (%)	Interval of application (DAS)				Mean
	30 (I <sub>1</sub> )	30 + 45 (I <sub>2</sub> )	45 + 60 (I <sub>3</sub> )	30 + 45 + 60 (I <sub>4</sub> )	
0 (C <sub>1</sub> )	9.2	9.1	9.1	9.2	9.15
10 (C <sub>2</sub> )	9.6	10.5	10.3	10.5	10.20
20 (C <sub>3</sub> )	10.3	10.6	10.3	10.8	10.50
30 (C <sub>4</sub> )	10.1	10.5	10.3	10.5	10.35
Mean	9.80	10.20	10.00	10.30	
	Factor A	Factor B	Interaction (A x B)		
S.E. <sub>±</sub>	0.08	0.08	0.17		
CD at 5 %	0.25	0.25	N.S.		

N.S. = Non-significant

from 9.8 to 10.5 cm due to two foliar sprays of 20 per cent methanol. Adsul (1999) reported that the increase in concentration of foliar sprays of methanol increased the pod length of green gram from 7.2 cm for control to 9.5 cm for 3 foliar sprays of 20 per cent methanol.

#### **4.2.2 Thousand grain weight**

With increase in the concentration and number of foliar sprays of methanol, there was increase in the thousand seed weight of wheat (Table 11). The maximum grain weight was obtained due to 20 per cent methanol (C<sub>3</sub>) which was significantly superior to 10 per cent methanol (C<sub>2</sub>) and control (C<sub>1</sub>) but at par with 30 per cent methanol (C<sub>4</sub>).

Repeated applications of methanol (treatments I<sub>2</sub>, I<sub>3</sub> and I<sub>4</sub>) resulted in higher seed weight than single application (I<sub>1</sub>). The treatments I<sub>2</sub>, I<sub>3</sub> and I<sub>4</sub> were at par with each other. Among the treatment combinations, the maximum grain weight of wheat was obtained due to three foliar sprays of 20 per cent methanol at 30, 45 and 60 DAS (C<sub>3</sub>I<sub>4</sub>) which was higher than control (C<sub>1</sub>I<sub>1</sub>) by about 20 per cent. The interaction effects were found to be significant.

Salunkhe (1995) reported increase in 100 grain weight of wheat from 4.5 to 4.71 g due to two foliar sprays of 20 per cent methanol. Patil (1996) reported increase in 100 kernel weight of groundnut from 27.7 to 35.8 g and increase in 1000 seed weight of soybean from 115 to 121 g due to three foliar sprays of 20 per cent methanol.

Table 11. Effect of levels and number of foliar sprays of methanol on 1000 grain weight (g) of wheat

Concentration of methanol (%)	Interval of application (DAS)				Mean
	30 (I <sub>1</sub> )	30 + 45 (I <sub>2</sub> )	45 + 60 (I <sub>3</sub> )	30 + 45 + 60 (I <sub>4</sub> )	
0 (C <sub>1</sub> )	40.8	41.6	41.0	40.3	40.93
10 (C <sub>2</sub> )	43.5	44.5	43.5	46.0	44.38
20 (C <sub>3</sub> )	48.4	48.8	47.7	48.9	48.45
30 (C <sub>4</sub> )	46.7	48.1	47.7	48.5	47.75
Mean	44.85	45.75	44.98	45.93	
	Factor A	Factor B	Interaction (A x B)		
S.E. <sub>±</sub>	0.31	0.31	0.62		
CD at 5 %	0.92	0.92	1.84		

N.S. = Non-significant

Adsul (1999) reported that increase in concentration of foliar sprays of methanol increased the 1000 seed weight of green gram from 32.2 g for control to 39.3 g for 3 foliar sprays of 20 per cent methanol. The increase in concentration of methanol increased the 1000 weight of groundnut kernels from 780 g for control to 865 g for 3 foliar sprays of 20 per cent methanol (Ombase, 1999).

#### **4.2.3 Dry matter accumulation**

The data on total dry matter per plant of wheat as affected by the level and interval of application of methanol are given in Table 12. The maximum total dry weight per plant was observed with treatment C<sub>3</sub> which was significantly superior to the control (C<sub>1</sub>) but at par with C<sub>2</sub> and C<sub>4</sub>. The maximum total dry weight per plant was observed due to three foliar sprays of methanol (I<sub>4</sub>) which was at par with two foliar sprays of methanol (I<sub>2</sub> and I<sub>3</sub>). Treatments I<sub>2</sub> and I<sub>3</sub> were at par with control (I<sub>1</sub>). Among the treatment combinations, the maximum total dry matter per plant was obtained due to three foliar sprays of 20 per cent methanol (C<sub>3</sub>I<sub>4</sub>) which was higher than control (C<sub>1</sub>I<sub>1</sub>) by about 22 per cent. The interaction effects were found to be significant.

Application of photosynthesis improver Mixtalol has been reported to increase the dry matter content of plants like rice, maize, tomato (Venkatramani et al., 1987), *Brassica juncea* (Setia et al., 1989) and groundnut (Kothale et al., 1993a).

Table 12. Effect of levels and number of foliar sprays of methanol on total dry matter (g) per plant at harvest of wheat

Concentration of methanol (%)	Interval of application (DAS)				Mean
	30 (I <sub>1</sub> )	30 + 45 (I <sub>2</sub> )	45 + 60 (I <sub>3</sub> )	30 + 45 + 60 (I <sub>4</sub> )	
0 (C <sub>1</sub> )	16.0	16.9	16.5	16.7	16.53
10 (C <sub>2</sub> )	16.2	17.8	16.5	17.8	17.08
20 (C <sub>3</sub> )	17.5	17.5	18.9	19.5	18.35
30 (C <sub>4</sub> )	17.0	17.2	17.7	18.4	17.58
Mean	16.68	17.35	17.40	18.13	
	Factor A	Factor B	Interaction (A x B)		
S.E. <sub>±</sub>	0.25	0.25	0.50		
CD at 5 %	0.77	0.77	1.54		

N.S. = Non-significant

Salunkhe (1995) reported increase in the total dry matter per plant of wheat at harvest from 21.3 g for control to 23.6 g for two sprays of 20 per cent methanol. Mean dry matter accumulation per plant at harvest of groundnut and soybean increased with increase in the concentration of methanol from 0 to 20 per cent (Patil, 1996).

Increase in the dry matter accumulation due to foliar sprays of methanol has been reported in case of green gram from 32.2 g for control to 39.3 g for 3 foliar sprays of 20 per cent methanol at 25, 35 and 45 DAS (Adsul, 1999) and groundnut from 18.8 g for control to 28.1 g for 3 foliar sprays of methanol at 30, 45 and 60 DAS (Ombase, 1999).

#### **4.2.4 Grain yield**

All the foliar spray treatments significantly increased the grain yield of wheat over the control (Table 13 and Fig. 6). The grain yield was increased significantly with increase in the concentration of methanol upto 20 per cent (C<sub>3</sub>) and decreased at 30 per cent (C<sub>4</sub>). The treatment C<sub>3</sub> was at par with C<sub>4</sub>. Increase in the number of foliar sprays of methanol increased the grain yield of wheat. Treatments I<sub>1</sub>, I<sub>2</sub> and I<sub>3</sub> were at par with each other while I<sub>4</sub> was at par with I<sub>2</sub>. Among the treatment combinations, three foliar sprays of 20 per cent methanol (C<sub>3</sub>I<sub>4</sub>) resulted in about 21 per cent higher grain yield of wheat over the control (C<sub>1</sub>I<sub>1</sub>).

Application of photosynthesis improver Mixtalol has been reported to increase the grain yields of some crops like rice

Table 13. Effect of levels and number of foliar sprays of methanol on grain yield (q/ha) of wheat

Concentration of methanol (%)	Interval of application (DAS)				Mean
	30 (I <sub>1</sub> )	30 + 45 (I <sub>2</sub> )	45 + 60 (I <sub>3</sub> )	30 + 45 + 60 (I <sub>4</sub> )	
0 (C <sub>1</sub> )	41.2	41.5	41.5	42.5	41.68
10 (C <sub>2</sub> )	44.0	45.0	45.1	46.2	45.08
20 (C <sub>3</sub> )	46.0	48.2	46.2	48.4	47.20
30 (C <sub>4</sub> )	44.8	46.2	46.6	48.3	46.48
Mean	44.0	45.23	44.85	46.35	
	Factor A	Factor B	Interaction (A x B)		
S.E. <sub>±</sub>	0.46	0.46	0.92		
CD at 5 %	1.38	1.38	N.S.		

N.S. = Non-significant

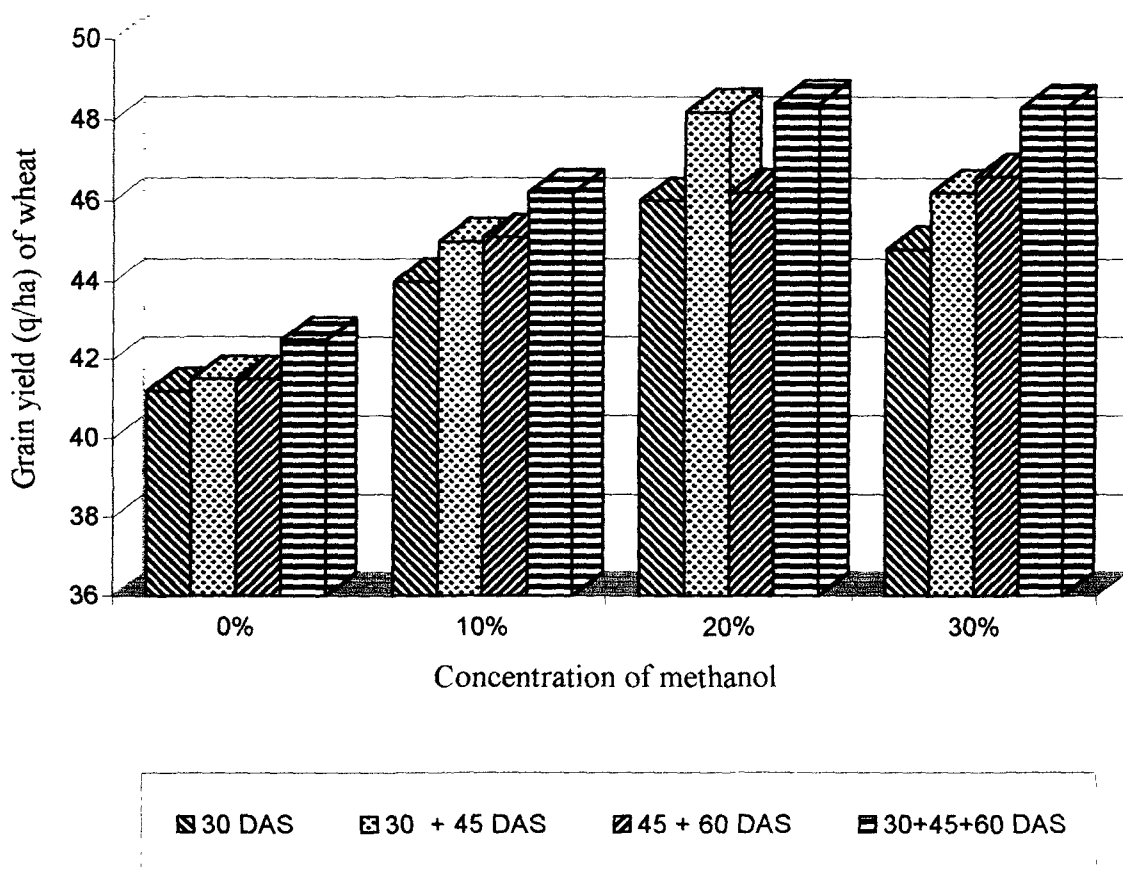


Fig. 6. Effect of levels and number of foliar sprays of methanol on grain yield (q/ha) of wheat

(Venkatramani et al., 1987), groundnut (Kothale et al., 1993b), barley (Ishwar Singh, 1993) and *Brassica napus* (rape) (Zhou et al., 1993, 1995).

Foliar sprays of methanol upto 20 per cent concentration have been reported to increase the grain yield of wheat, safflower from 44.4 to 52.8 q/ha and from 13.8 to 16.9 q/ha, respectively, due to two foliar sprays of 20 per cent methanol (Salunkhe, 1995). Kernel yield of groundnut and grain yield of soybean were increased from 8.8 to 13.7 q/ha and 18.1 to 20.6 q/ha, respectively, due to three foliar sprays of 20 per cent methanol (Patil, 1996). The grain yield of summer green gram was increased from 19.6 to 27.9 q/ha due to 3 foliar sprays of 20 per cent methanol (Adsul, 1999) and kernel yield of summer groundnut was increased from 18.3 to 25.7 q/ha due to 3 foliar sprays of 20 per cent methanol (Ombase, 1999).

The results obtained in the present study support the earlier reports.

#### **4.2.5 Straw yield**

The straw yield of wheat was increased significantly with increase in the concentration of methanol upto 20 per cent (C<sub>3</sub>) and decreased at 30 per cent (Table 14). Treatments C<sub>3</sub> and C<sub>4</sub> are at par with each other but significantly superior over control (C<sub>1</sub>). The highest straw yield was obtained by three foliar sprays of methanol (I<sub>4</sub>) followed by two sprays I<sub>2</sub>, I<sub>3</sub> and one spray (I<sub>1</sub>). The treatment I<sub>2</sub> was at par with I<sub>3</sub>. Among the treatment combinations, the highest

Table 14. Effect of levels and number of foliar sprays of methanol on straw yield (q/ha) of wheat

Concentration of methanol (%)	Interval of application (DAS)				Mean
	30 (I <sub>1</sub> )	30 + 45 (I <sub>2</sub> )	45 + 60 (I <sub>3</sub> )	30 + 45 + 60 (I <sub>4</sub> )	
0 (C <sub>1</sub> )	58.0	57.0	59.2	58.2	58.10
10 (C <sub>2</sub> )	58.2	61.2	61.0	65.0	61.35
20 (C <sub>3</sub> )	60.0	65.2	64.8	70.2	65.04
30 (C <sub>4</sub> )	58.0	62.2	60.3	63.2	60.93
Mean	58.55	61.14	61.35	64.15	
	Factor A	Factor B	Interaction (A x B)		
S.E. <sub>±</sub>	0.8	0.8	1.6		
CD at 5 %	2.4	2.4	N.S.		

N.S. = Non-significant

straw yield of wheat was obtained due to three foliar sprays of 20 per cent methanol at 30, 45 and 60 DAS (C<sub>3</sub>I<sub>4</sub>) which was about 21 per cent higher than the control (C<sub>1</sub>I<sub>1</sub>). The interaction effects were found to be non-significant.

Salunkhe (1995) reported that the straw yield of wheat and safflower significantly increased with increase in the concentration of methanol from 5 to 30 per cent. Maximum straw yield was obtained with 20 per cent methanol. Patil (1996) obtained maximum straw yield of soybean and haulm yield of groundnut due to two foliar sprays of 20 per cent methanol. Adsul (1999) reported increase in straw yield from 24.9 to 30.9 q/ha due to 3 foliar sprays of 20 per cent methanol. Haulm yield in groundnut increased from 101.4 to 108.9 q/ha due to 20 per cent methanol (Ombase, 1999). The results obtained in the present study are in conformity with the above reports.

### **4.3 Chemical analysis of wheat plant**

#### **4.3.1 Concentrations of N, P and K in wheat plant**

##### **4.3.1.1 Nitrogen**

The nitrogen content in wheat plants was increased with increase the concentration of methanol (Table 15). N content of treatment C<sub>3</sub> was significantly higher than the rest of the treatments. Treatment C<sub>2</sub> was at par with C<sub>4</sub> and control (C<sub>1</sub>).

The highest N content in plants was observed by three foliar sprays of methanol (I<sub>4</sub>) which was at par with two foliar sprays

Table 15. Effect of levels and number of foliar sprays of methanol on N content (%) of wheat plant

Concentration of methanol (%)	Interval of application (DAS)				Mean
	30 (I <sub>1</sub> )	30 + 45 (I <sub>2</sub> )	45 + 60 (I <sub>3</sub> )	30 + 45 + 60 (I <sub>4</sub> )	
0 (C <sub>1</sub> )	0.21	0.23	0.22	0.23	0.223
10 (C <sub>2</sub> )	0.21	0.24	0.23	0.25	0.233
20 (C <sub>3</sub> )	0.24	0.25	0.24	0.26	0.248
30 (C <sub>4</sub> )	0.23	0.24	0.23	0.24	0.235
Mean	0.223	0.240	0.230	0.245	
	Factor A	Factor B	Interaction (A x B)		
S.E. <sub>±</sub>	0.003	0.003	0.006		
CD at 5 %	0.010	0.010	N.S.		

N.S. = Non-significant

of methanol given at early stage (at 30 and 45 DAS) (I<sub>2</sub>). Treatment T<sub>3</sub> was par with I<sub>2</sub> and control (I<sub>1</sub>). Among the treatment combinations, the highest N content in plants of wheat was obtained due to three foliar sprays of 20 per cent methanol at 30, 45 and 60 DAS (C<sub>3</sub>I<sub>4</sub>) which was about 24 per cent higher than the control (C<sub>1</sub>I<sub>1</sub>). Interaction effects were found to be non-significant.

#### 4.3.1.2 Phosphorus

It was observed that P content of wheat plants was increased significantly due to application of 20 and 30 per cent methanol (Table 16). The treatment C<sub>3</sub> was at par with C<sub>4</sub> while treatment C<sub>2</sub> was at par with C<sub>4</sub> and control (C<sub>1</sub>).

The number of foliar sprays and their time of application did not have significant influence on the phosphorus content of wheat plants. Among the treatment combinations the highest P content in plants was obtained due to three foliar sprays of 20 per cent methanol at 30, 45 and 60 DAS (C<sub>3</sub>I<sub>4</sub>) was about 60 per cent higher than the control (C<sub>1</sub>I<sub>1</sub>). The interaction effects found to be non-significant.

#### 4.3.1.3 Potassium

The K content of wheat plants was increased with increase in the concentration of methanol upto 20 per cent (C<sub>3</sub>) and decreased at 30 per cent (C<sub>4</sub>) (Table 17). Treatment C<sub>3</sub> was superior to rest of the treatments. The treatments C<sub>2</sub> and C<sub>4</sub> were at par with each other. Increase in the number of foliar sprays of methanol increased

Table 16. Effect of levels and number of foliar sprays of methanol on P content (%) of wheat plant

Concentration of methanol (%)	Interval of application (DAS)				Mean
	30 (I <sub>1</sub> )	30 + 45 (I <sub>2</sub> )	45 + 60 (I <sub>3</sub> )	30 + 45 + 60 (I <sub>4</sub> )	
0 (C <sub>1</sub> )	0.10	0.10	0.11	0.09	0.100
10 (C <sub>2</sub> )	0.11	0.12	0.12	0.12	0.118
20 (C <sub>3</sub> )	0.13	0.14	0.14	0.16	0.143
30 (C <sub>4</sub> )	0.13	0.12	0.13	0.13	0.128
Mean	0.118	0.120	0.125	0.125	
	Factor A	Factor B	Interaction (A x B)		
S.E. <sub>+</sub>	0.006	0.006	0.012		
CD at 5 %	0.018	N.S.	N.S.		

N.S. = Non-significant

Table 17. Effect of levels and number of foliar sprays of methanol on K content (%) of wheat plants

Concentration of methanol (%)	Interval of application (DAS)				Mean
	30 (I <sub>1</sub> )	30 + 45 (I <sub>2</sub> )	45 + 60 (I <sub>3</sub> )	30 + 45 + 60 (I <sub>4</sub> )	
0 (C <sub>1</sub> )	1.14	1.13	1.14	1.12	1.13
10 (C <sub>2</sub> )	1.17	1.23	1.20	1.30	1.23
20 (C <sub>3</sub> )	1.22	1.30	1.28	1.35	1.29
30 (C <sub>4</sub> )	1.17	1.20	1.22	1.28	1.22
Mean	1.18	1.22	1.21	1.26	
	Factor A	Factor B	Interaction (A x B)		
S.E. <sub>±</sub>	0.011	0.011	0.022		
CD at 5 %	0.035	0.035	0.070		

N.S. = Non-significant

the K content of wheat plants. The treatments I<sub>4</sub> was significantly higher than the rest of the treatments. The treatment I<sub>2</sub> was at par with I<sub>3</sub>. Among the treatment combinations, the highest K content in wheat plants was obtained due to three foliar sprays of 20 per cent methanol at 30, 45 and 60 DAS (C<sub>3</sub>I<sub>4</sub>) which was about 18 per cent higher than the control (C<sub>1</sub>I<sub>1</sub>). The interaction effects were found to be significant.

The increase in N content of plants due to application of photosynthesis improver triacontanol has been reported in case of rice and maize (Quian et al., 1981; Richard and Ries, 1981).

The foliar sprays of methanol have been reported to increase the N, P, K concentration of wheat from 0.23 to 0.37 per cent, 0.1 to 0.18 per cent and 1.12 to 1.45 per cent, respectively, of safflower from 0.37 to 0.56 per cent, 0.14 to 0.19 per cent and 1.95 to 2.37 per cent, respectively (Salunkhe, 1995), of groundnut from 1.35 to 1.83 per cent, 0.47 to 0.6 per cent and of soybean from 1 to 1.45 per cent, 0.45 to 0.56 per cent and 1.17 to 1.30 per cent, respectively (Patil, 1996). Adsul (1999) reported increased N, P, K concentration of green gram plants from 0.21 to 0.7 per cent, 0.11 to 0.16 per cent and 0.85 to 0.94 per cent, respectively due to 3 foliar sprays of 20 per cent methanol.

### **4.3.2 Nutrient uptake by plants**

#### **4.3.2.1 Nitrogen**

Uptake of nitrogen was increased with increase in the concentration of methanol upto 20 per cent (C<sub>3</sub>) and decreased at 30 per cent (C<sub>4</sub>) (Table 18, Fig. 7). The treatment C<sub>3</sub> was significantly superior to rest of the treatments. Treatments C<sub>2</sub> and C<sub>4</sub> were at par with each other but significantly superior over the control. N uptake by wheat plants was significantly increased with increase in the number of foliar sprays of methanol. The treatments I<sub>2</sub> and I<sub>3</sub> were at par with each other. Among the treatment combinations, the highest N uptake by wheat plants was obtained due to three foliar sprays of 20 per cent methanol at 30, 45 and 60 DAS (C<sub>3</sub>I<sub>4</sub>) which was about 21 per cent higher than the control (C<sub>1</sub>I<sub>1</sub>). The interaction effects were found to be significant.

#### **4.3.2.2 Phosphorus**

The P uptake by plants followed similar trend as in case of N uptake (Table 19, Fig. 8). Treatments I<sub>2</sub> and I<sub>3</sub> were at par with each other and also with control (I<sub>1</sub>) while treatment I<sub>4</sub> was superior to control but at par with I<sub>2</sub> and I<sub>3</sub>. Among the treatment combinations, the highest P uptake by wheat plants was obtained due to three. Foliar sprays of 20 per cent methanol (C<sub>3</sub>I<sub>4</sub>) which was 65 per cent higher than the control (C<sub>1</sub>I<sub>1</sub>). The interaction effects were found to be significant.

Table 18. Effect of levels and number of foliar sprays of methanol on N uptake (kg/ha) of wheat plant

Concentration of methanol (%)	Interval of application (DAS)				Mean
	30 (I <sub>1</sub> )	30 + 45 (I <sub>2</sub> )	45 + 60 (I <sub>3</sub> )	30 + 45 + 60 (I <sub>4</sub> )	
0 (C <sub>1</sub> )	74.5	76.7	75.7	75.1	75.5
10 (C <sub>2</sub> )	78.4	82.0	85.0	85.5	82.7
20 (C <sub>3</sub> )	82.2	86.5	84.0	90.2	85.7
30 (C <sub>4</sub> )	78.0	83.5	83.0	87.0	82.9
Mean	78.3	82.2	81.9	85.5	
	Factor A	Factor B	Interaction (A x B)		
S.E. <sub>±</sub>	0.64	0.64	1.27		
CD at 5 %	1.91	1.91	3.82		

N.S. = Non-significant

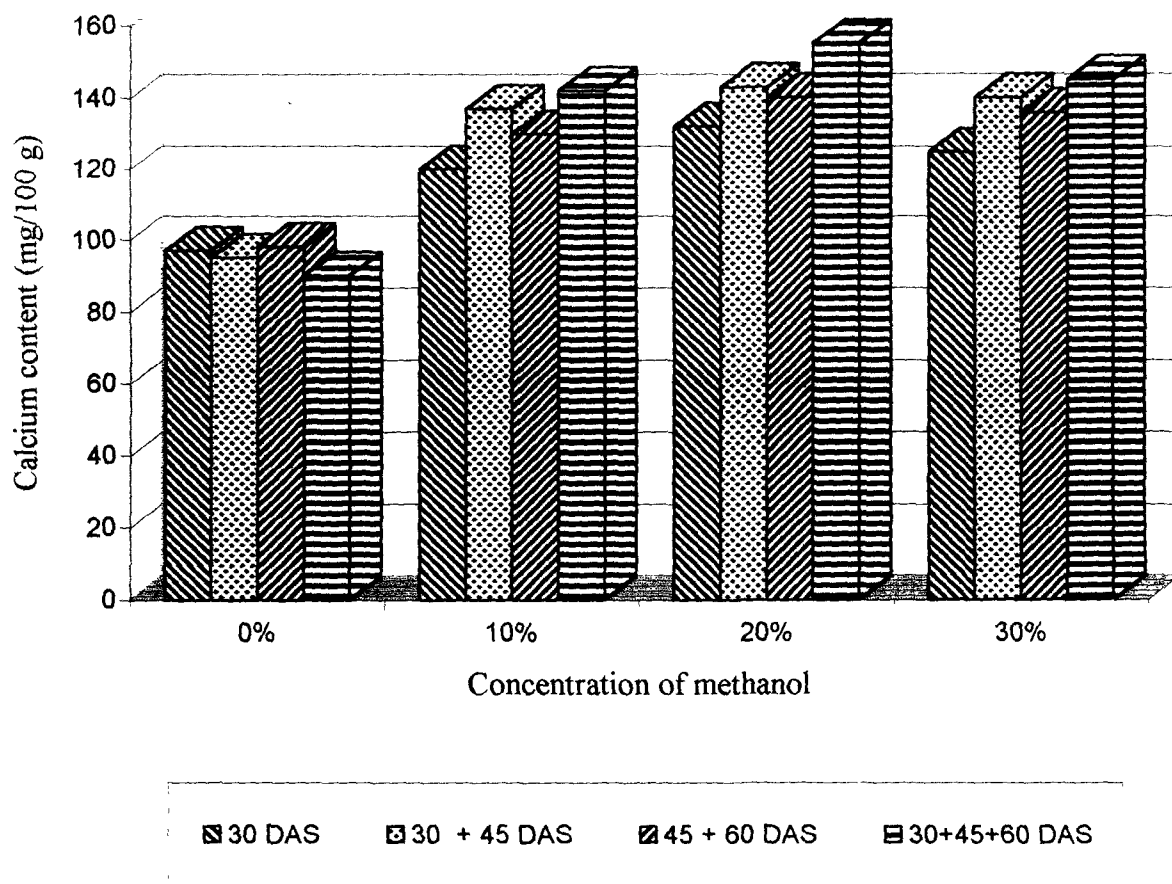


Fig. 12. Effect of levels and number of foliar sprays of methanol on calcium content (mg/100 g) of wheat grains

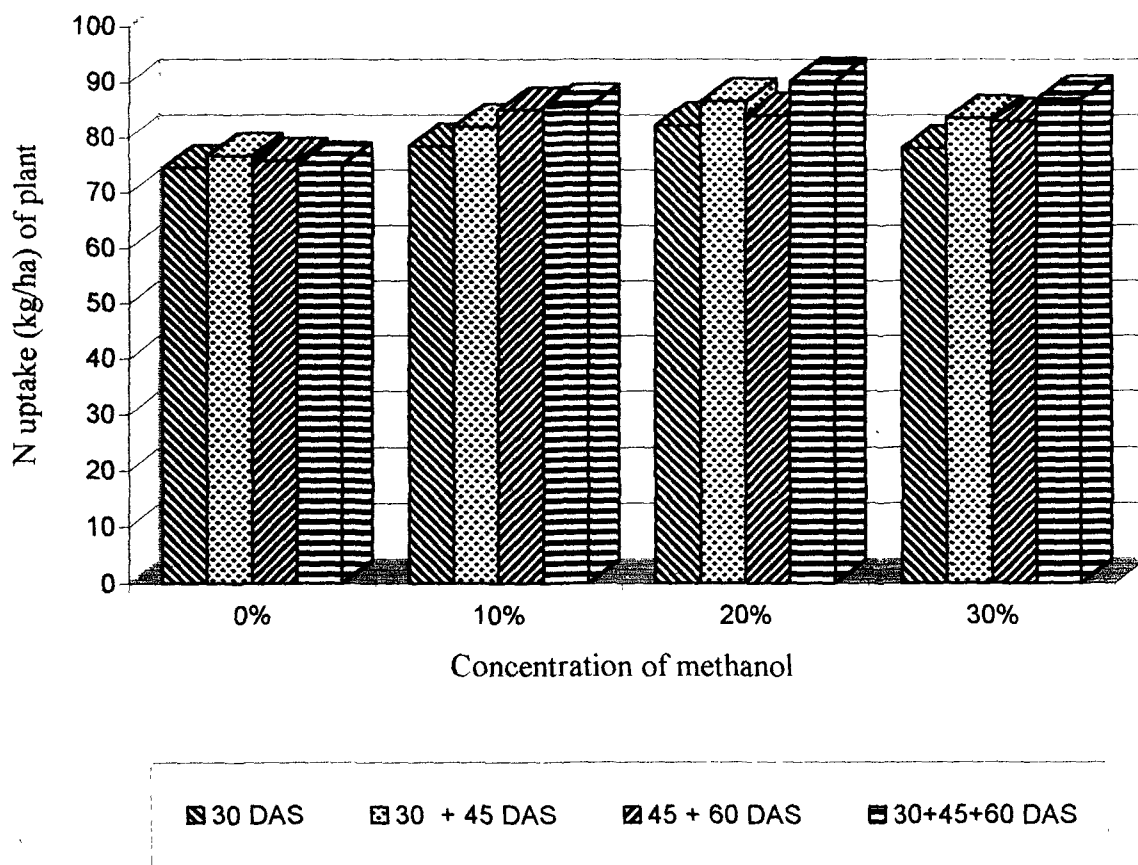


Fig. 7. Effect of levels and number of foliar sprays of methanol on N uptake (kg/ha) of wheat plant

Table 19. Effect of levels and number of foliar sprays of methanol on P uptake (kg/ ha) of wheat plant

Concentration of methanol (%)	Interval of application (DAS)				Mean
	30 (I <sub>1</sub> )	30 + 45 (I <sub>2</sub> )	45 + 60 (I <sub>3</sub> )	30 + 45 + 60 (I <sub>4</sub> )	
0 (C <sub>1</sub> )	11.2	11.7	11.9	11.4	11.6
10 (C <sub>2</sub> )	14.8	16.8	15.8	17.6	16.3
20 (C <sub>3</sub> )	16.6	17.7	18.2	18.5	17.8
30 (C <sub>4</sub> )	15.5	17.2	16.2	18.0	16.7
Mean	14.5	15.9	15.5	16.5	
	Factor A	Factor B	Interaction (A x B)		
S.E.+	0.48	0.48	0.96		
CD at 5 %	1.44	1.44	2.88		

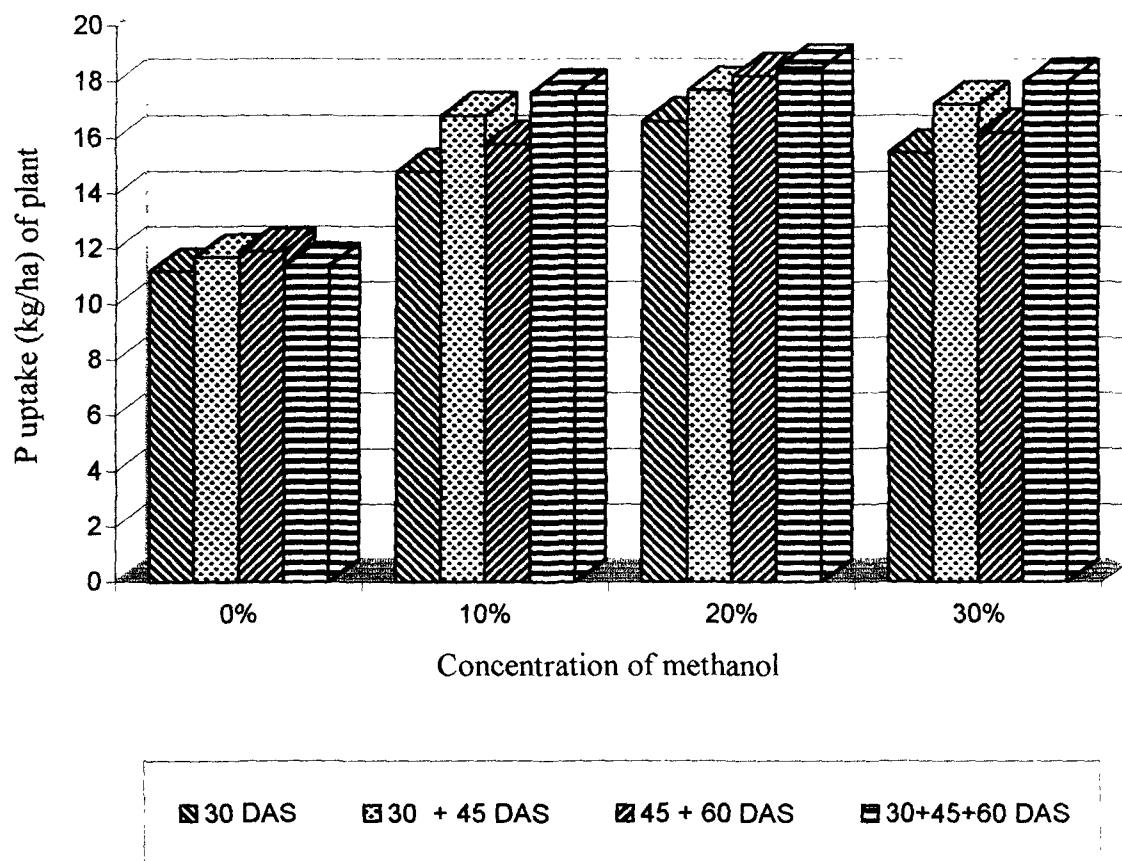


Fig. 8. Effect of levels and number of foliar sprays of methanol on P uptake (kg/ha) of wheat plant

### **4.3.2.3 Potassium**

The K uptake by wheat plants also followed same trend as in case of N uptake (Table 20, Fig. 9). The highest K uptake by wheat plants was obtained due to three foliar sprays of 20 per cent methanol (C<sub>3</sub>I<sub>4</sub>) which was higher than control (C<sub>1</sub>I<sub>1</sub>) by about 58 per cent. The interaction effects were found to be significant.

The results presented in Table 18, 19 and 20 and Fig. 7, 8, 9 are in conformity with those of Salunkhe (1995) who reported that the uptake of N, P and K by wheat and safflower plants increased due to foliar spray of methanol. The highest N, P, K uptake was observed with two foliar sprays of 20 per cent methanol. The uptake of N, P and K by groundnut and soybean plants has been reported to increase with increase in the concentration from 5 to 20 per cent and decreased at 30 per cent (Patil, 1996). Similar increase in N, P, K uptake due to foliar application of methanol has been reported in green gram (Adsul, 1999) and groundnut plants (Ombase, 1999).

## **4.4 Chemical composition of grains**

### **4.4.1 Moisture**

The moisture content in wheat grains did not increase significantly either due to increase in concentration or the number of foliar sprays of methanol (Table 21).

Moisture content was non-significantly increased due to foliar sprays of methanol in case of wheat and safflower grains

Table 20. Effect of levels and number of foliar sprays of methanol on K uptake (kg/ha) of wheat plant

Concentration of methanol (%)	Interval of application (DAS)				Mean
	30 (I <sub>1</sub> )	30 + 45 (I <sub>2</sub> )	45 + 60 (I <sub>3</sub> )	30 + 45 + 60 (I <sub>4</sub> )	
0 (C <sub>1</sub> )	55.3	55.9	54.8	54.4	55.1
10 (C <sub>2</sub> )	62.8	68.0	67.9	72.8	67.9
20 (C <sub>3</sub> )	68.0	77.0	79.7	87.2	78.0
30 (C <sub>4</sub> )	60.3	69.7	68.0	76.0	69.1
Mean	61.6	68.1	67.2	75.9	
	Factor A	Factor B	Interaction (A x B)		
S.E. <sub>±</sub>	0.69	0.69	1.38		
CD at 5 %	2.07	2.07	4.14		

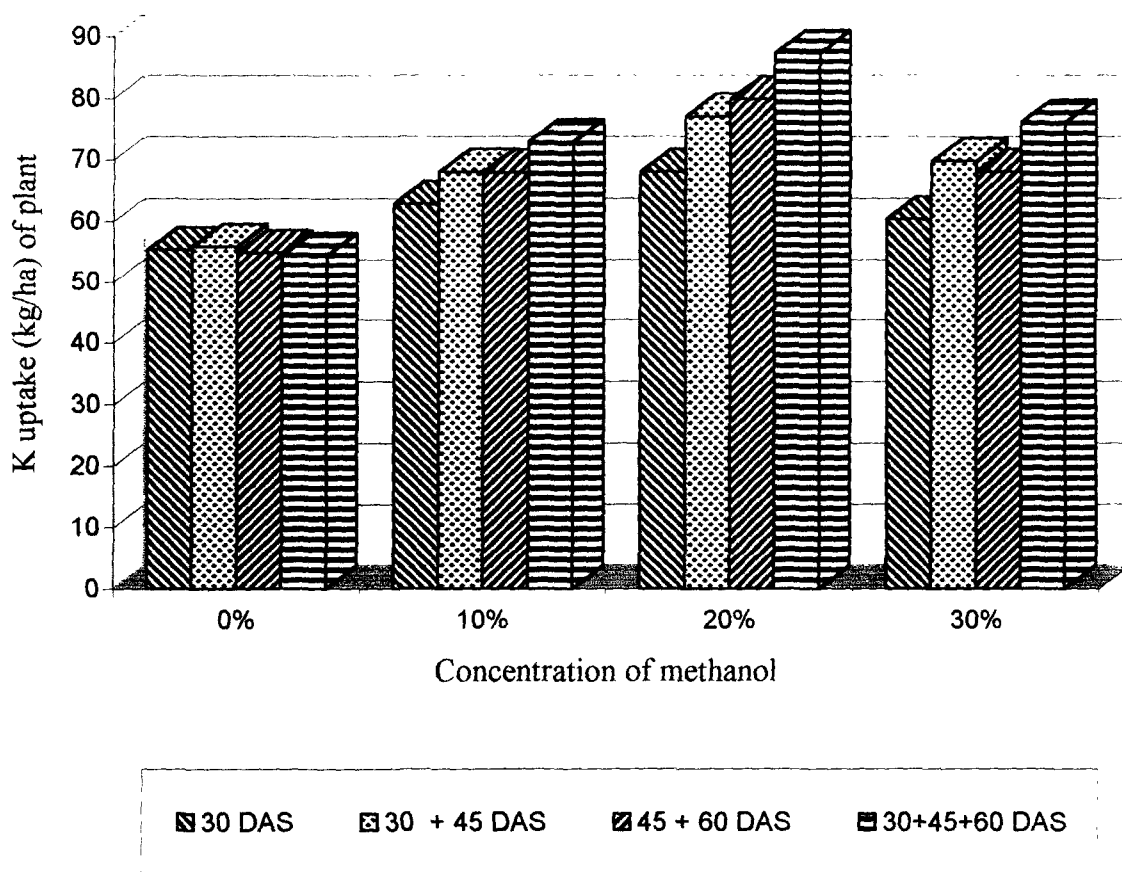


Fig. 9. Effect of levels and number of foliar sprays of methanol on K uptake (kg/ha) of wheat plant

Table 21. Effect of levels and number of foliar sprays of methanol on moisture content (%) in grains of wheat

Concentration of methanol (%)	Interval of application (DAS)				Mean
	30 (I <sub>1</sub> )	30 + 45 (I <sub>2</sub> )	45 + 60 (I <sub>3</sub> )	30 + 45 + 60 (I <sub>4</sub> )	
0 (C <sub>1</sub> )	9.8	9.5	9.7	9.9	9.68
10 (C <sub>2</sub> )	10.2	10.5	10.2	10.8	10.42
20 (C <sub>3</sub> )	10.4	10.8	10.5	10.5	10.55
30 (C <sub>4</sub> )	10.1	10.5	10.3	10.6	10.38
Mean	10.12	10.32	10.18	10.45	
	Factor A	Factor B	Interaction (A x B)		
S.E. <sub>±</sub>	0.38	0.38	0.76		
CD at 5 %	N.S.	N.S.	N.S.		

N.S. = Non significant

(Salunkhe, 1995). Similar results were obtained by Patil (1996) in case of groundnut and soybean, Adsul (1999) in case of summer green gram and Ombase (1999) in case of summer groundnut.

#### **4.4.2 Carbohydrates**

The carbohydrate content in wheat grains was decrease with increase in the concentration of methanol upto 20 per cent (C<sub>1</sub>) and increased at 30 per cent (C<sub>4</sub>) (Table 22 and Fig. 10). Treatment C<sub>1</sub> (Control) recorded the highest carbohydrate content which was significantly higher than the rest of the treatments. The treatments C<sub>1</sub> and C<sub>4</sub> were at par with each other but were significantly superior over C<sub>3</sub>. The maximum carbohydrate content in grains was observed by one foliar spray of methanol (I<sub>1</sub>) which was significantly higher than I<sub>4</sub> and I<sub>2</sub> but at par with I<sub>3</sub>. Among the treatment combinations the lowest carbohydrate content in grains of wheat was obtained due to three foliar sprays of 20 per cent methanol at 30, 45 and 60 DA (C<sub>3</sub>I<sub>4</sub>). The interaction effects were found to be significant.

Total carbohydrate content of wheat seeds has been shown about 83 per cent of the total dry matter (Adsule and Kadam 1986).

Adsul (1999) reported decrease in carbohydrate content in green gram from 65 per cent (control) to 55.1 per cent due to three foliar sprays of 20 per cent methanol at 25, 35 and 45 DAS. Similarly carbohydrate content in groundnut decreased from 19.8 per cent due

Table 22. Effect of levels and number of foliar sprays of methanol on carbohydrate content (%) in grains of wheat

Concentration of methanol (%)	Interval of application (DAS)				Mean
	30 (I <sub>1</sub> )	30 + 45 (I <sub>2</sub> )	45 + 60 (I <sub>3</sub> )	30 + 45 + 60 (I <sub>4</sub> )	
0 (C <sub>1</sub> )	85.0	84.9	85.2	84.9	85.0
10 (C <sub>2</sub> )	84.2	83.1	83.7	82.1	83.3
20 (C <sub>3</sub> )	83.3	82.1	82.8	81.1	82.3
30 (C <sub>4</sub> )	84.0	82.6	83.5	81.7	83.0
Mean	84.1	83.2	83.8	82.5	
	Factor A	Factor B	Interaction (A x B)		
S.E. <sub>±</sub>	0.17	0.17	0.34		
CD at 5 %	0.53	0.53	1.06		

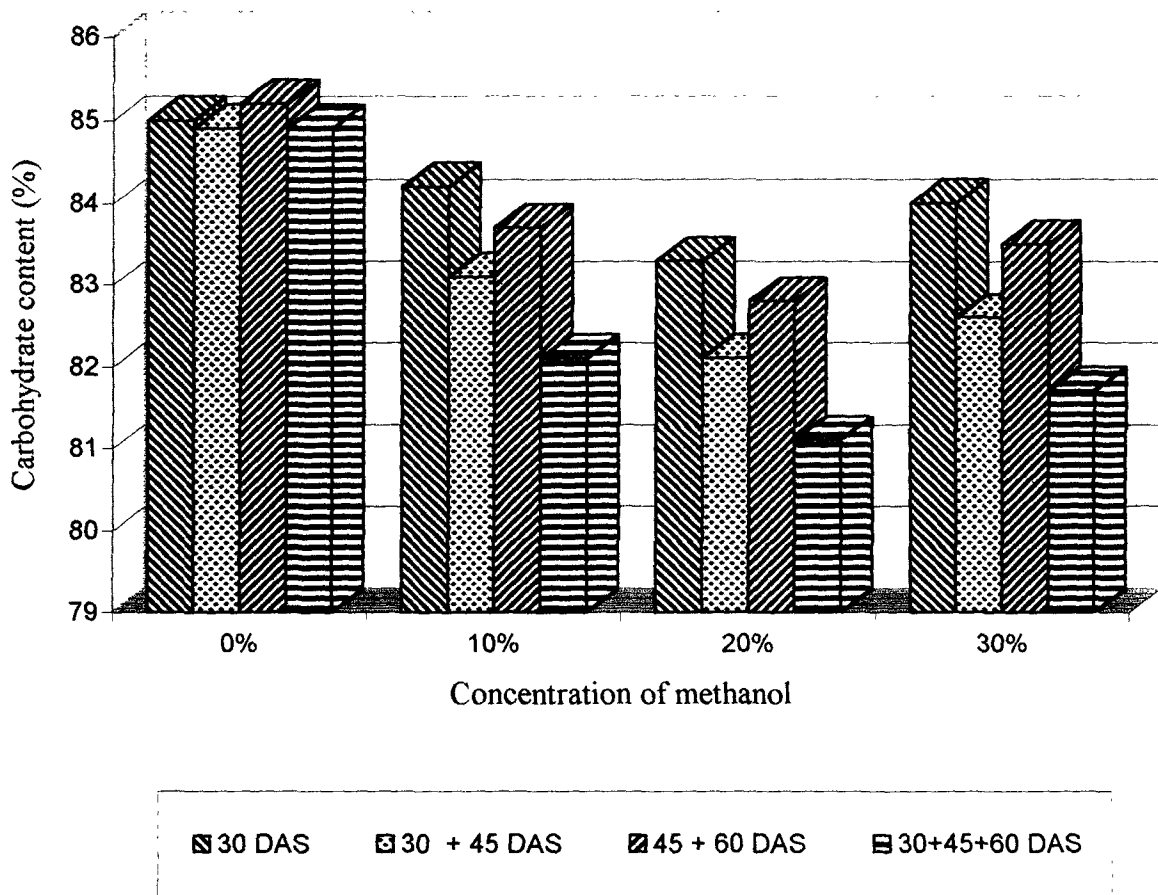


Fig. 10. Effect of levels and number of foliar sprays of methanol on carbohydrate content (%) in grains of wheat

to control to 12.2 per cent due to three foliar sprays of 20 per cent methanol at 30, 45 and 60 DAS (Ombase, 1999).

#### **4.4.3 Protein**

The protein content in wheat seeds was increased with increase in the concentration of methanol upto 20 per cent (C<sub>3</sub>) and decreased at 30 per cent (C<sub>4</sub>) (Table 23, Fig. 11). Protein content due to treatment C<sub>3</sub> was superior to C<sub>1</sub> and C<sub>2</sub> but at par with C<sub>4</sub>. Treatment C<sub>4</sub> was at par with C<sub>2</sub>. The highest protein content was observed by three foliar sprays of methanol (I<sub>4</sub>) which was at par with 2 foliar sprays of methanol at early stages (I<sub>2</sub>). I<sub>3</sub> (two sprays at 45 and 60 DAS) was at par with treatment I<sub>2</sub> (two foliar sprays at 30 and 45 DAS) and I<sub>1</sub> (control). Among the treatment combinations, the highest protein content in grains of wheat was obtained due to three foliar sprays of 20 per cent methanol at 30, 45 and 60 DAS (C<sub>3</sub>I<sub>4</sub>). Which was higher than control (C<sub>1</sub>I<sub>1</sub>) by about 28.6 per cent. The interaction effect were found to be non-significant.

Protein content of wheat seeds varies significantly from 5.6 to 21 per cent (Mattern et al., 1970). The results are in conformity with Salunkhe (1995) who reported that protein content of wheat grains and safflower seeds was increased with increase in the concentration of methanol from 5 to 20 per cent. Protein production per ha of groundnut and soyabean was increased with increase in the concentration of methanol upto 20 per cent and declined thereafter (Patil, 1996).

Table 23. Effect of levels and number of foliar sprays of methanol on protein content (%) in grains of wheat

Concentration of methanol (%)	Interval of application (DAS)				Mean
	30 (I <sub>1</sub> )	30 + 45 (I <sub>2</sub> )	45 + 60 (I <sub>3</sub> )	30 + 45 + 60 (I <sub>4</sub> )	
0 (C <sub>1</sub> )	11.2	11.3	11.0	11.3	11.2
10 (C <sub>2</sub> )	11.8	12.7	12.2	13.6	12.6
20 (C <sub>3</sub> )	12.6	13.6	13.0	14.4	13.4
30 (C <sub>4</sub> )	12.0	13.2	12.4	13.9	12.9
Mean	11.9	12.7	12.2	13.3	
	Factor A	Factor B	Interaction (A x B)		
S.E.±	0.25	0.25	0.5		
CD at 5 %	0.75	0.75	N.S.		

N.S. = Non-significant

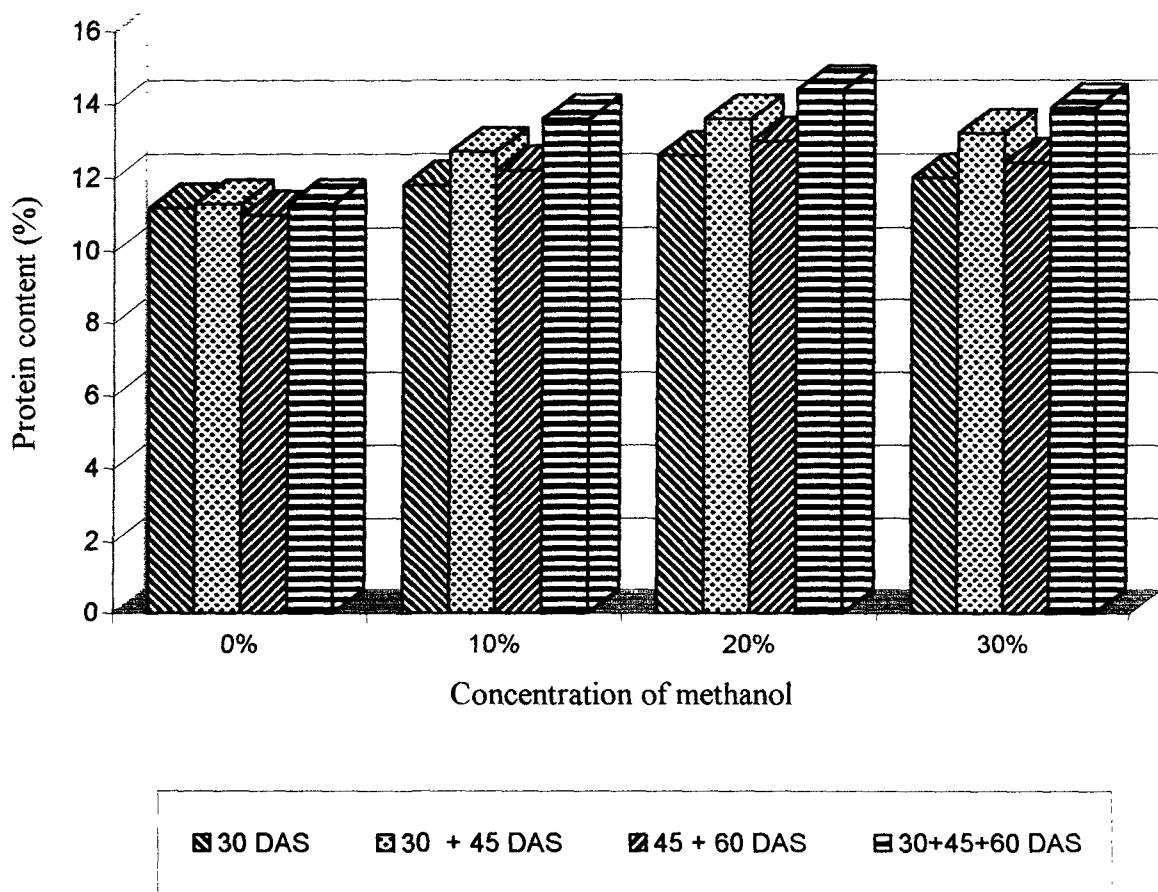


Fig.11. Effect of levels and number of foliar sprays of methanol on protein content (%) in grains of wheat

Adsul (1999) reported increase in the protein content of green gram seeds from 20.6 per cent (control) to 29.3 per cent due to three foliar sprays of 20 per cent methanol at 25, 35 and 45 DAS. Ombase (1999) reported that increase in the concentration of foliar spray of methanol increased the protein content of groundnut kernels from 25.8 per cent (control) to 29.2 per cent due to 3 foliar sprays of 20 per cent methanol at 30, 45 and 60 DAS.

#### 4.4.4 Fat

The fat content of wheat grains was increased due to foliar sprays of methanol (Table 24). Treatments C<sub>3</sub>, C<sub>2</sub> and C<sub>4</sub> were at par with each other but were significantly superior over control. Similarly treatments I<sub>2</sub>, I<sub>3</sub> and I<sub>4</sub> were at par with each other while I<sub>1</sub> was at par with I<sub>2</sub> and I<sub>3</sub>. Among the treatment combinations, the highest fat content in grains of wheat was obtained due to three foliar sprays of 20 per cent methanol at 30, 45 and 60 DAS (C<sub>3</sub>I<sub>4</sub>). The interaction effects were found to be non-significant.

The lipid content of wheat kernels is about 2.0 per cent with extreme variations between 0.88 to 3.9 per cent (Miller, 1958; Davis et al. (1980), Sharma et al. (1989) reported highest oil content of soybean under Mixtalol treatment sprayed at 4-leaf stage of soybean crop. Salunkhe (1995) obtained maximum oil content in the safflower seeds with two foliar sprays of 20 per cent methanol. Oil content in groundnut kernels and soybean seeds increased with increase in the concentration of methanol upto 20 per cent and declined thereafter

Table 24. Effect of levels and number of foliar sprays of methanol on fat content (%) in grains of wheat

Concentration of methanol (%)	Interval of application (DAS)				Mean
	30 (I <sub>1</sub> )	30 + 45 (I <sub>2</sub> )	45 + 60 (I <sub>3</sub> )	30 + 45 + 60 (I <sub>4</sub> )	
0 (C <sub>1</sub> )	2.14	2.15	2.15	2.12	2.14
10 (C <sub>2</sub> )	2.25	2.38	2.35	2.50	2.35
20 (C <sub>3</sub> )	2.34	2.48	2.40	2.60	2.46
30 (C <sub>4</sub> )	2.30	2.42	2.32	2.50	2.39
Mean	2.26	2.36	2.31	2.42	
	Factor A	Factor B	Interaction (A x B)		
S.E. <sub>±</sub>	0.04	0.04	0.09		
CD at 5 %	0.128	0.128	N.S.		

N.S. = Non-significant

(Patil, 1996). Adsul (1999) reported that increase in concentration of methanol increased the fat content of green gram seeds from 1.13 per cent (control) to 1.23 per cent due to 3 foliar sprays of 20 per cent methanol at 25, 35 and 45 DAS. Similarly, oil content in groundnut kernels increased from 46.6 (control) to 48.3 per cent due to 3 foliar sprays of 20 per cent methanol at 30, 45 and 60 DAS (Ombase, 1999).

#### **4.4.5 Ash**

The ash content in wheat grains was increased due to application of methanol over the control (Table 25). Treatments C<sub>2</sub>, C<sub>3</sub> and C<sub>4</sub> were at par with each other. The number of foliar sprays did not have significant on the ash content. Among the treatment combinations the highest ash content in grains of wheat was obtained due to three foliar sprays of 20 per cent methanol at 30, 45 and 60 DAS (C<sub>3</sub>I<sub>4</sub>) which was about 15 per cent higher than the control (C<sub>1</sub>I<sub>1</sub>). The interaction effects were found to be non-significant.

Salunkhe (1995) reported that ash content of wheat and safflower was significantly increased with increase in the concentration of methanol upto 20 per cent. Patil (1996) reported highest ash content of groundnut and soybean as a result of applications of 20 per cent methanol. Adsul (1999) reported increase in ash content of green gram from 3.41 per cent (control) to 3.53 per cent due to 3 foliar sprays of 20 per cent methanol at 25, 35 and 45 DAS. Ombase (1999) found ash content of groundnut increased from

Table 25. Effect of levels and number of foliar sprays of methanol on ash content (%) of wheat grains

Concentration of methanol (%)	Interval of application (DAS)				Mean
	30 (I <sub>1</sub> )	30 + 45 (I <sub>2</sub> )	45 + 60 (I <sub>3</sub> )	30 + 45 + 60 (I <sub>4</sub> )	
0 (C <sub>1</sub> )	1.64	1.64	1.65	1.68	1.65
10 (C <sub>2</sub> )	1.72	1.81	1.76	1.85	1.78
20 (C <sub>3</sub> )	1.79	1.84	1.80	1.88	1.83
30 (C <sub>4</sub> )	1.74	1.82	1.75	1.86	1.79
Mean	1.72	1.78	1.74	1.82	
	Factor A	Factor B	Interaction (A x B)		
S.E. <sub>±</sub>	0.03	0.03	0.06		
CD at 5 %	0.10	N.S.	N.S.		

N.S. = Non-significant

2.52 per cent (control) to 2.99 per cent due to 3 foliar sprays of 20 per cent methanol at 30, 45 and 60 DAS.

#### 4.4.6 Calcium

The calcium content of wheat grains was increased with increase in the number of foliar sprays and increase in the concentration of methanol upto 20 per cent (C<sub>3</sub>) and decreased at 30 per cent (C<sub>4</sub>) (Table 26 and Fig. 12). The treatment differences were highly significant. Among the treatment combinations, the highest calcium content was obtained due to C<sub>3</sub>I<sub>4</sub> which was about 60 per cent higher than the control (C<sub>1</sub>I<sub>1</sub>).

The wheat seeds have been reported to contain 103 to 217 mg calcium/100g (Booth et al., 1946). Adsul (1999) found that increase in concentration of foliar spray of methanol from control to 20 per cent increased the calcium content in green gram from 108 to 142 mg/100 g, while increase from 59 to 72 mg/100 g was found in groundnut (Ombase, 1999) in same type of experiment. The increase in concentration of calcium in wheat seeds due to foliar spray of methanol may be due to increased uptake of minerals, including calcium and their translocation to the seed.

#### 4.4.7 Iron

It was observed that iron content of wheat seeds increased significantly with increase in the concentration of methanol (Table 27, Fig. 13). Treatment C<sub>4</sub> was at par with C<sub>2</sub> and C<sub>3</sub>. Three foliar sprays (I<sub>4</sub>) resulted in significantly higher Fe content of wheat

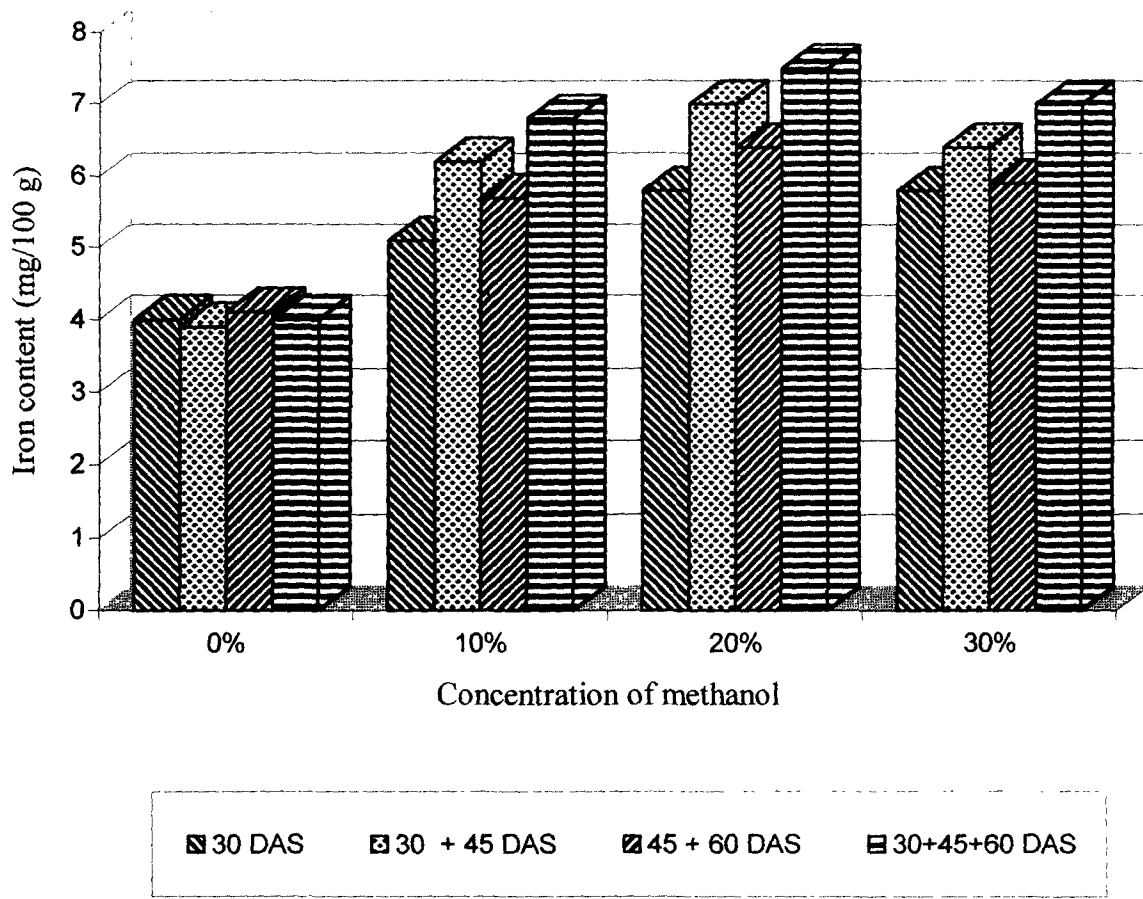


Fig. 13. Effect of levels and number of foliar sprays of methanol on iron content (mg/100 g) of wheat grains

Table 26. Effect of levels and number of foliar sprays of methanol on calcium content (mg/100 g) of wheat grains

Concentration of methanol (%)	Interval of application (DAS)				Mean
	30 (I <sub>1</sub> )	30 + 45 (I <sub>2</sub> )	45 + 60 (I <sub>3</sub> )	30 + 45 + 60 (I <sub>4</sub> )	
0 (C <sub>1</sub> )	97	95	98	90	95.0
10 (C <sub>2</sub> )	120	137	130	142	131.8
20 (C <sub>3</sub> )	132	143	140	155	142.5
30 (C <sub>4</sub> )	125	140	136	145	136.5
Mean	118.5	128.3	126.0	133.0	
	Factor A	Factor B	Interaction (A x B)		
S.E.±	0.76	0.76	1.52		
CD at 5 %	2.3	2.3	4.6		

Table 27. Effect of levels and number of foliar sprays of methanol on iron content (mg/100 g) of wheat grains

Concentration of methanol (%)	Interval of application (DAS)				Mean
	30 (I <sub>1</sub> )	30 + 45 (I <sub>2</sub> )	45 + 60 (I <sub>3</sub> )	30 + 45 + 60 (I <sub>4</sub> )	
0 (C <sub>1</sub> )	4.0	3.9	4.1	4.0	4.0
10 (C <sub>2</sub> )	5.1	6.2	5.7	6.8	5.95
20 (C <sub>3</sub> )	5.8	7.0	6.4	7.5	6.68
30 (C <sub>4</sub> )	5.8	6.4	5.9	7.0	6.28
Mean	5.8	5.88	5.52	6.35	
	Factor A	Factor B	Interaction (A x B)		
S.E.±	0.23	0.23	0.46		
CD at 5 %	0.70	0.70	1.40		

grains than one foliar spray (I<sub>1</sub>). Treatments I<sub>1</sub>, I<sub>2</sub> and I<sub>3</sub> were at par with each other. The application of 3 sprays of 20 per cent methanol (C<sub>3</sub>I<sub>4</sub>) had the highest iron content among the treatment combinations. Which was about 88 per cent higher than the control (C<sub>1</sub>I<sub>1</sub>).

Wheat seeds have been reported to contain 1.84 to 8.55 mg iron/100 g (Booth et al., 1946). Adsul (1999) reported increase in calcium content of green gram seeds from 108 (control) to 142 mg/100 g due to 20 per cent methanol as foliar spray at 3 stages. Ombase (1999) found increase in calcium content of groundnut kernels from 59 (control) to 72 mg/100 g due to 3 foliar sprays of 20 per cent methanol.

The increase in concentration of iron in wheat seeds due to foliar spray of methanol may be due to increased uptake of minerals, including iron and their translocation to the seed.

#### **4.4.8 Phosphorus**

The phosphorus content of grains was increased with increase in the concentration of methanol. Treatment C<sub>3</sub> was significantly superior over C<sub>1</sub> and C<sub>2</sub> but was at par with C<sub>4</sub>. The maximum phosphorus content was observed by three sprays (I<sub>4</sub>) which was significantly superior over I<sub>1</sub> and I<sub>3</sub> but was at par with I<sub>2</sub>. Among the treatment combinations, the phosphorus content from C<sub>3</sub>I<sub>4</sub> combination was higher than control (C<sub>1</sub>I<sub>1</sub>) by 78 per cent.

Wheat seeds have been reported to contain 190 to 567 mg phosphorus/100 g (Booth et al., 1946). Adsul (1999) reported increase in phosphorus content in green gram seeds from 327 mg/100 g (control) to 474 mg/100 g due to 3 foliar sprays of 20 per cent methanol. Phosphorus content in groundnut kernels increased from 340 mg/100 g to 470 mg/100 g as a result of increase in concentration of methanol from control to 20 per cent (Ombase, 1999).

The increase in concentration of phosphorus in wheat seeds due to foliar spray of methanol may be due to increased uptake of minerals, including phosphorus and its translocation to the seeds.

#### **4.4.9 Methionine**

All the foliar spray treatments of methanol significantly increased the methionine content in grains over the control (Table 29, Fig. 15). Treatment C<sub>3</sub> was significantly superior over treatments C<sub>1</sub> and C<sub>2</sub> but was at par with C<sub>4</sub>. Treatments C<sub>2</sub> and C<sub>4</sub> were at par with each other. The maximum methionine content was observed by three foliar sprays (I<sub>4</sub>) which was superior to one spray (I<sub>1</sub>) and at par with two sprays (I<sub>3</sub> and I<sub>2</sub>). Among the treatment combinations, the highest methionine content was observed in case of C<sub>3</sub>I<sub>4</sub> which was higher than control by about 11 per cent.

#### **4.4.10 Tryptophan**

Tryptophan content of wheat seed proteins was increased due to the foliar spray of methanol as in the case of tryptophan (Table 30, Fig. 16). Treatment C<sub>3</sub> was significantly superior to control C<sub>1</sub> but

Table 29. Effect of levels and number of foliar sprays of methanol on methionine content (g/16 g N) in grains of wheat

Concentration of methanol (%)	Interval of application (DAS)				Mean
	30 (I <sub>1</sub> )	30 + 45 (I <sub>2</sub> )	45 + 60 (I <sub>3</sub> )	30 + 45 + 60 (I <sub>4</sub> )	
0 (C <sub>1</sub> )	1.10	1.12	1.10	1.10	1.11
10 (C <sub>2</sub> )	1.13	1.15	1.14	1.18	1.15
20 (C <sub>3</sub> )	1.16	1.20	1.18	1.22	1.19
30 (C <sub>4</sub> )	1.14	1.18	1.16	1.20	1.17
Mean	1.13	1.16	1.15	1.18	
	Factor A	Factor B	Interaction (A x B)		
S.E. <sub>±</sub>	0.01	0.01	0.02		
CD at 5 %	0.03	0.03	0.06		

N.S. = Non-significant

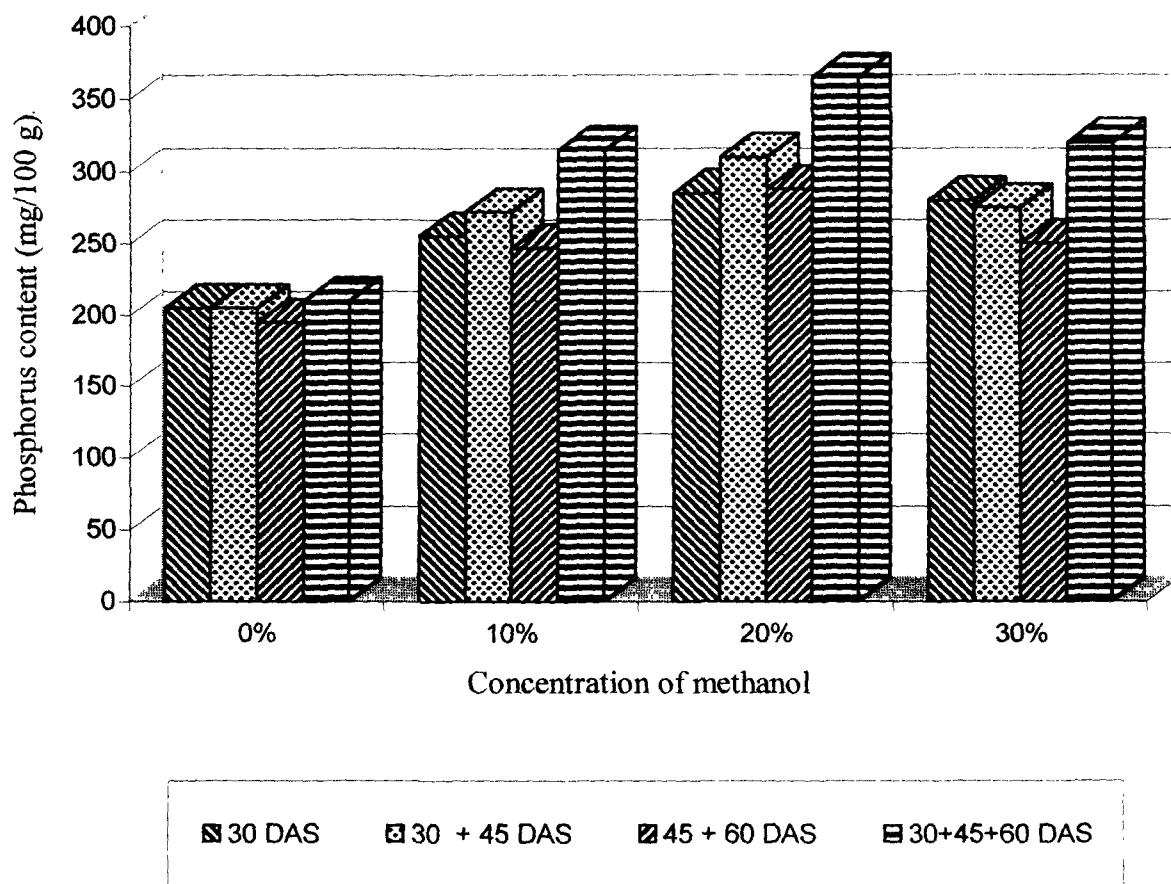


Fig. 14. Effect of levels and number of foliar sprays of methanol on phosphorus content (mg/100 g) of wheat grains

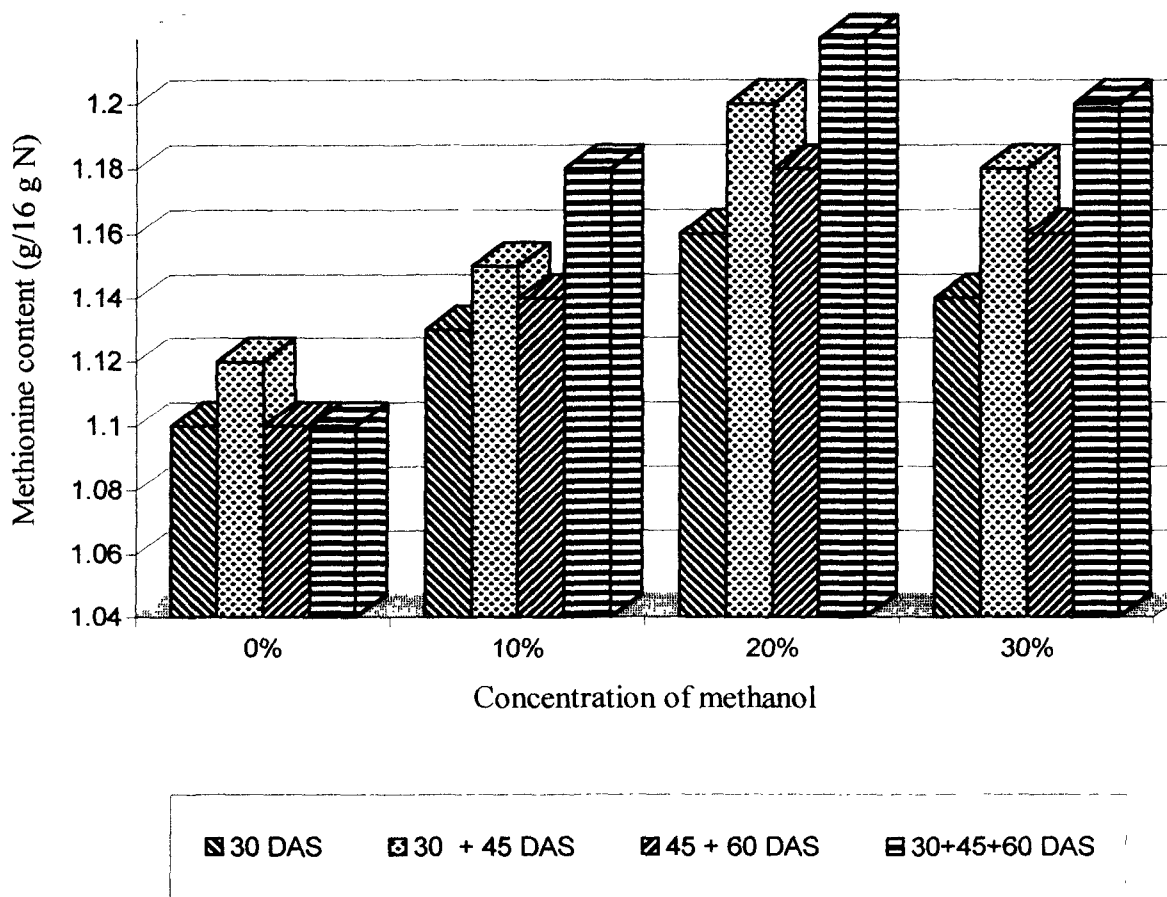


Fig. 15. Effect of levels and number of foliar sprays of methanol on methionine content (g/16 g N) in grains of wheat

Table 30. Effect of levels and number of sprays of methanol on tryptophan (g/16 g N) of wheat grains

Concentration of methanol (%)	Interval of application (DAS)				Mean
	30 (I <sub>1</sub> )	30 + 45 (I <sub>2</sub> )	45 + 60 (I <sub>3</sub> )	30 + 45 + 60 (I <sub>4</sub> )	
0 (C <sub>1</sub> )	1.35	1.35	1.38	1.36	1.36
10 (C <sub>2</sub> )	1.40	1.45	1.40	1.50	1.44
20 (C <sub>3</sub> )	1.45	1.52	1.48	1.52	1.49
30 (C <sub>4</sub> )	1.42	1.48	1.45	1.52	1.47
Mean	1.41	1.45	1.43	1.48	
	Factor A	Factor B	Interaction (A x B)		
S.E. <sub>±</sub>	0.02	0.02	0.04		
CD at 5 %	0.05	0.05	N.S.		

N.S. = Non-significant

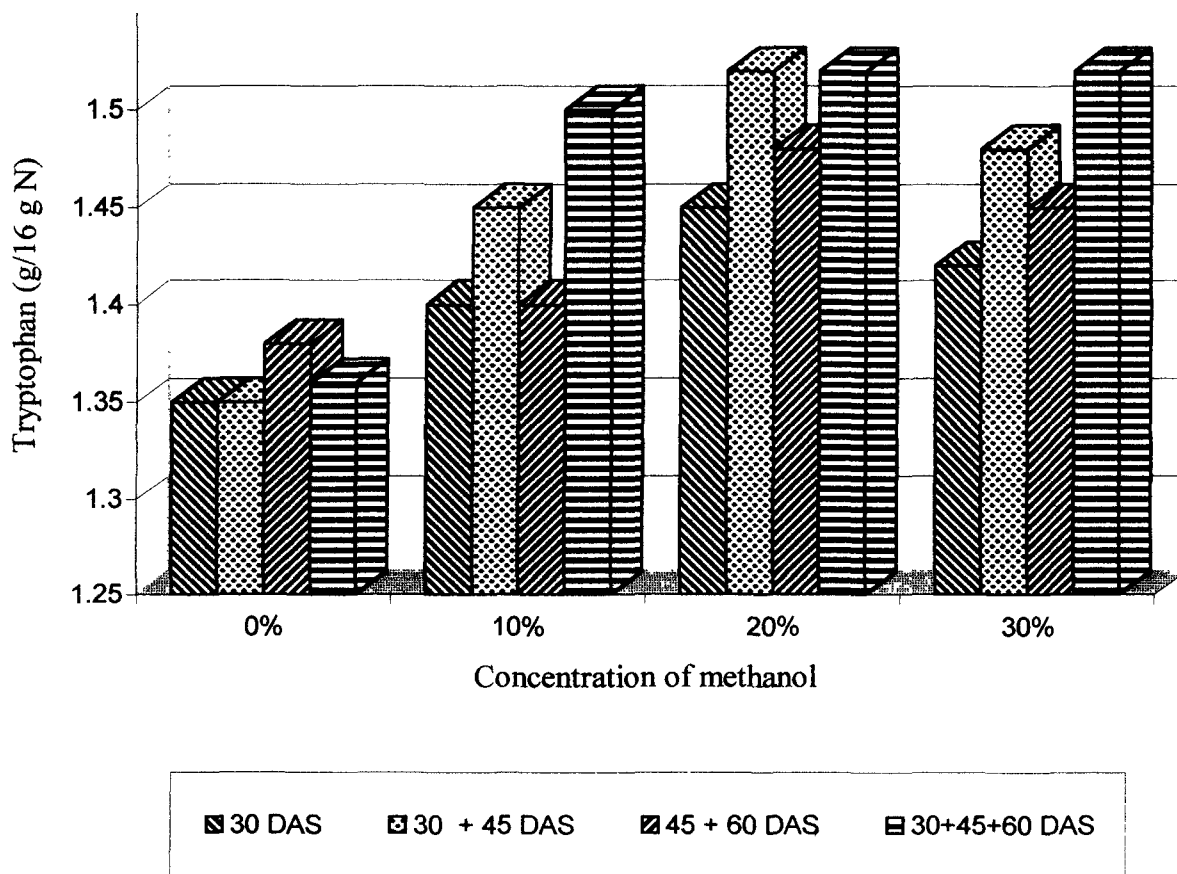


Fig. 16. Effect of levels and number of foliar sprays of methanol on tryptophan (g/16 g N) of wheat grains

at par with C<sub>2</sub> and C<sub>4</sub>. Maximum tryptophan content in grains was observed by three foliar sprays (I<sub>4</sub>) followed by two foliar sprays (I<sub>2</sub> and I<sub>3</sub>) and one foliar spray (I<sub>1</sub>). Treatment I<sub>2</sub> was at par with I<sub>1</sub>, I<sub>3</sub> and I<sub>4</sub>. Treatment I<sub>4</sub> was significantly superior over I<sub>1</sub> but was at par with I<sub>2</sub> and I<sub>3</sub>. Among the treatment combinations, the highest tryptophan content of wheat seed proteins was obtained due to three foliar sprays of 20 per cent methanol at 30, 45 and 60 DAS (C<sub>3</sub>I<sub>4</sub>) which was higher than control (C<sub>1</sub>I<sub>1</sub>) by about 13 per cent. The interaction effects were found to be non-significant.

Wheat seed proteins have been reported to contain about 1.2 g methionine 1.5 g tryptophan per 16 g N (Bushuk and Wrigley, 1974). Adsul (1999) reported that with increase in concentration of methanol spray from control to 20 per cent the methionine and tryptophan contents of green gram seed increased from 0.91 g/16 g N to 1.52 g/16 g N and from 0.39 g/16 g N to 0.61 g/16 g N, respectively. Similarly, the methionine and tryptophan contents of groundnut kernel were found to increase from 0.72 g/100 g protein (control) to 0.92 g/100 g proteins and 0.71 g/100 g protein (control) to 0.85 g/100 g protein, respectively; due to 20 per cent methanol (Ombase, 1999).

The increase in methionine and tryptophan contents of wheat seed proteins observed in the present study may be due to the increased uptake of nitrogen by wheat plants (Table 18) and its

translocation to developing seeds for synthesis of methionine, tryptophan and other amino acids and proteins.

#### **Benefit-cost ratio**

The data presented in Table 5 to 30 indicated that most of the plant growth, yield and quality parameters of wheat were improved with increase in the number of sprays and increase in the concentration of methanol upto 20 per cent. The differences in the two sprays given either at early growth stages (30 + 45 DAS) or at late growth stages (45 + 60 DAS), found to be non-significant in most of the cases. The results indicated that three foliar sprays of 20 per cent methanol at 30, 45 and 60 DAS were optimum for improving the yield and quality of wheat.

Table 31. Benefit-cost ratio of wheat as influenced by foliar spray of methanol

Treatments	Cost of methanol (Rs.)	Cost of Spraying (Rs.)	Addl. cost (Rs.)	Addt. yield (q)		Additional returns (Benefit) (Rs.)			Benefit cost ratio
				Grain	Straw	Grain	Straw	Total	
C <sub>1</sub> I <sub>1</sub>	-	-	-	-	-	-	-	-	-
C <sub>1</sub> I <sub>2</sub>	-	-	-	-	-	-	-	-	-
C <sub>1</sub> I <sub>3</sub>	-	-	-	-	-	-	-	-	-
C <sub>1</sub> I <sub>4</sub>	-	-	-	-	-	-	-	-	-
C <sub>2</sub> I <sub>1</sub>	360	80	440	2.32	0.1	1392.0	1.0	1393.0	3.16
C <sub>2</sub> I <sub>2</sub>	840	160	100	3.32	3.1	1992.0	31.0	2023.0	2.02
C <sub>2</sub> I <sub>3</sub>	1080	160	1240	3.42	2.9	2052.0	29.0	2081.0	1.68
C <sub>2</sub> I <sub>4</sub>	1440	240	1680	4.52	6.9	2712.0	69.0	2781.0	1.65
C <sub>3</sub> I <sub>1</sub>	720	80	800	4.32	1.9	2592.0	19.0	2611.0	3.26
C <sub>3</sub> I <sub>2</sub>	1680	160	1840	6.52	7.1	3912.0	71.0	3983.0	2.16
C <sub>3</sub> I <sub>3</sub>	2160	160	2320	4.52	6.7	2712.0	67.0	2779.0	1.20
C <sub>3</sub> I <sub>4</sub>	2880	240	3120	6.72	12.1	4032.0	121.0	4153.0	1.33
C <sub>4</sub> I <sub>1</sub>	1080	80	1160	3.12	0.1	1872.0	-1.0	1871.0	1.61
C <sub>4</sub> I <sub>2</sub>	2520	160	2680	4.52	4.1	2712.0	41.0	2753.0	1.03
C <sub>4</sub> I <sub>3</sub>	3240	160	3400	4.92	2.2	2952.0	22.0	2974.0	0.87
C <sub>4</sub> I <sub>4</sub>	4320	240	4560	6.62	5.1	3972.0	51.0	4023.0	0.88

\* All values and calculations are on per ha basis

Labour charges : Rs. 80/labour

Grain price : Rs. 600/q.

Straw price : Rs. 10/q

Cost of methanol : Rs. 12.00/litre

Labour requirement for spraying : 2 labours/day

(All the costs and prices are as per the rates during 1996-97)

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# **SUMMARY AND CONCLUSIONS**

2. The leaf area and leaf chlorophyll content of wheat were significantly influenced by methanol spray. The highest leaf area and chlorophyll content were observed due to three foliar sprays of 20 per cent methanol at 30, 45 and 60 DAS.
3. The length of earhead and the average grain weight were increased by 17.4 and 20 per cent over the control due to three foliar sprays of 20 per cent methanol.
4. The total dry matter accumulation in wheat plants increased by about 22 per cent over the control due to three foliar sprays of 20 per cent methanol.
5. The application of methanol significantly increased the grain and straw yields of wheat. The foliar application of three sprays of 20 per cent methanol resulted in the highest grain and straw yields which were higher than control by about 17.5 per cent and 21 per cent, respectively.
6. Nitrogen, phosphorus and potassium concentrations in wheat plant were increased by about 24, 60 and 18 per cent respectively due to 3 foliar sprays of 20 per cent methanol. Nitrogen, phosphorus and potassium uptake were also increased significantly with increase in methanol concentration. The values obtained due to three foliar sprays of 20 per cent methanol were 21, 65, 58 per cent higher than the control.
7. Protein and ash contents in wheat seeds were increased while carbohydrate content was decreased due to the foliar

application of methanol. Three foliar sprays of 20 per cent methanol at 30, 45 and 60 DAS resulted in 29 per cent and 15 per cent higher protein and ash contents respectively, than the control.

8. Foliar sprays of methanol increased the fat content but did not affect the moisture content of wheat grains.
9. The calcium, iron and phosphorus contents of wheat seeds were significantly increased over the control due to increase in concentration of methanol. Three sprays of 20 per cent methanol treatment were found to result in 60, 88 and 78 per cent higher Ca, Fe and P content of wheat seeds than the control.
10. The foliar sprays of methanol slightly increased the methionine and tryptophan contents in wheat seeds proteins. Wheat seed proteins from plants with three foliar sprays of 20 per cent methanol contained about 11 per cent more methionine and about 13 per cent more tryptophan than the control.

The results obtained in the present investigation indicated that the increase in the number of sprays and the concentration of methanol in the spray had significant influence on growth, yield and quality of wheat. The concentration of methanol higher than 20 per cent was found to be toxic to wheat plant and had adverse effect on the plant growth and yield of wheat. Increasing number of sprays from one to three improved the plant growth and

yield of wheat. Among the different treatment combinations of methanol tried, 20 per cent methanol application as foliar spray at 30, 45 and 60 DAS was found to give maximum yield and quality of wheat.

However, these results are based on the single season's data and using only one variety of wheat. The results need to be confirmed by conducting additional field trials using large number of varieties and for number of seasons at different locations to arrive at definite conclusions.

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**LITERATURE CITED**

## 6. LITERATURE CITED

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**\* Originals are not seen.**

Chapter Opener Page

**VITA**

## 7. VITA

**Vivek Suresh Patil**

A candidate for the degree

*of*

MASTER OF SCIENCE (AGRICULTURE)

*in*

AGRICULTURAL CHEMISTRY

2000

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Title of the thesis : "Effect of concentration and foliar sprays of methanol on growth, yield and quality of wheat".

Major field : Agricultural Chemistry

Biographical information :

\* Personal : Born at Zodge, Tal. Malegaon, Dist. Nashik on 1st June, 1975. Son of Shri. Suresh Narayan Patil and Sau. Ashalata Suresh Patil. Having one sister Ku. Sharmila and one brother Anand.

\* Educational : Attended Primary School at Manmad, Tal. Nandgaon, Dist. Nashik.  
: Attended Secondary School at Dhule and Passed S.S.C. in 1990, with Ist Class with distinction  
: Attended Higher Secondary School at Jai-Hind College, Dhule and passed H.S.C. in 1992, with Ist Class.

- : Graduated in Agriculture, from College of Agriculture, Dhule and got B.Sc. (Agri.) degree with Ist Class in 1996.
- \* Other corricular activities : Completed N.C.C. course at both levels Junior Division ('A' certificate) and Senior Division ('B' and 'C' certificate).
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