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RESPONSE OF SUNFLOWER CULTIVARS TO LEVELS OF PHOSPHORUS IN RABI SEASON

By

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CERTIFICATE

Ms. **VANI SREE. V** has satisfactorily prosecuted the course of research and that the thesis entitled "**RESPONSE OF SUNFLOWER CULTIVARS TO LEVELS OF PHOSPHORUS IN RABI SEASON**" submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that the thesis or part thereof has not been previously submitted by her for a degree of any university.

16.10.97

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CERTIFICATE

This is to certify that the thesis entitled "**RESPONSE OF SUNFLOWER CULTIVARS TO LEVELS OF PHOSPHORUS IN RABI SEASON**" submitted in partial fulfilment of the requirements for the degree of **Master of Science** in Agriculture in the major field of **Agronomy** of the Acharya N.G. Ranga Agricultural University, Hyderabad is a record of the bonafide research work carried out by Ms. **VANI SREE.V** under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee.

No part of the thesis has been submitted for any other degree or diploma. The published part has been fully acknowledged. All the assistance and help received during the course of the investigation have been duly acknowledged by the author of the thesis.

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DECLARATION

I, Ms. **VANI SREE.V** hereby declare that the thesis entitled "**RESPONSE OF SUNFLOWER CULTIVARS TO LEVELS OF PHOSPHORUS IN <u>RABI</u> SEASON**" submitted to the Acharya N.G. Ranga Agricultural University for the degree of Master of Science in Agriculture in the major field of Agronomy is the result of original research work done by me. I also declare that any material contained in the thesis has not been published earlier.

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ABSTRACT

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A field experiment entitled "Response of sunflower cultivars to levels of phosphorus in rabi season" was conducted on transported clay loam soils of Agricultural College Farm, Bapatla, during rabi 1996-'97. The treatments consisted of four sunflower hybrids viz., APSH-11, KBSH-1, MSFH-8 and MEGA-363 assigned to main plots and four levels of phosphorus viz., 0, 30, 60 and 90 kg P_2O_5 ha^{-1} assigned to sub-plots. The experiment was laid out in split-plot design with three replications.

Among different sunflower hybrids, MSFH-8 recorded significantly higher plant height than MEGA-363 and KBSH-1 and higher dry matter than APSH-11 and KBSH-1. APSH-11, KBSH-1 and MEGA-363 came to 50% flowering earlier than

MSFH-8. In respect of number of filled seeds and filled seed weight per head and filling percentage MSFH-8 performed better over others. Head diameter and head weight were highest in MEGA-363 and was at a par with APSH-11 in head diameter and with MSFH-8 in head weight. KBSH-1 had significantly more test weight than others. The minimum of all the above yield attributes (except test weight) were recorded in KBSH-1. MSFH-8 recorded significantly higher seed yield and possessed higher oil content followed by MEGA-363, APSH-11 and KBSH-1, respectively. Higher stalk yield was obtained in MEGA-363 and MSFH-8 over other two hybrids. Higher H.I. Harvest Index was recorded both in MSFH-8 and APSH-11 than others. The uptake of P both by seed and stalk was significantly higher in MSFH-8, but was at a par with MEGA-363 in terms of P uptake by stalk.

Phosphorus levels had no significant influence on growth parameters, yield attributes, yield (seed, stalk and oil), oil content and P uptake at all stages except at 30 DAS in dry matter accumulation, LAI and P uptake.

From the present study it can be inferred that for South Coastal region of Andhra Pradesh, in clay loam soils MSFH-8 was found to perform better than other hybrids viz., MEGA-363, APSH-11 and KBSH-1 during <u>rabi</u> season.

LIST OF ABBREVIATIONS

@	:	at the rate of
^{o}C	:	degree celsius
CD	:	critical difference
cm	:	centimeter
CV	:	coefficient of variation
DAS	:	Days after sowing
dSm^{-1}	:	deci Siemens per meter
EC	:	Electrical conductivity
Fig.	:	Figure
g	:	grams
$g\ kg^{-1}$	:	gram per kilogram
$g\ m^{-2}$	:	gram per square meter
ha^{-1}	:	per hectare
HI	:	Harvest index
K	:	Potassium
$kg\ ha^{-1}$	:	kilogram per hectare
$kg\ P_2O_5\ ha^{-1}$	:	kilogram phosphorus pentoxide per hectare
K_2O	:	Potassium oxide
LAI	:	Leaf area index
$LE\ ha^{-1}$	:	Larval equivalents per hectare
m	:	meter
mm	:	millimeter
N	:	Nitrogen
NPV	:	Nuclear polyhedrosis virus

LIST OF ABBREVIATIONS Contd...

NS	:	non-significant
P	:	Phosphorus
P_2O_5	:	Phosphorus pentoxide
q ha^{-1}	:	quintal per hectare
SEm$\pm$	:	Standard error of mean
viz.,	:	namely
%	:	per cent

Introduction

CHAPTER - I

INTRODUCTION

Growing demand for edible oil in India is making the planners to explore the ways to increase the production of edible oil. The traditional oilseed crops viz., groundnut, rapeseed-mustard and sesamum although grown in an area of 161.86 lakh hectares but the production of oilseeds is far less (Directorate of Economics and Statistics, 1995) which is not sufficient to meet the demand. The above situation can be overcome by promoting the cultivation of non-traditional oilseed crops like sunflower (Sen, 1979).

Sunflower in recent years is established as one of the important oilseed crops in India. Sunflower is an ideal crop because of its good inherent characteristics such as photo insensitivity, wider adaptability, short duration, high per cent (40-45) of good quality oil (rich in poly-unsaturated fatty acids), high protein content (15%), saline and drought tolerance capacity.

In Andhra Pradesh the sunflower is grown in an area of 3.96 lakh hectares during 1995-'96 with a production of 2.83 lakh tonnes (Directorate of Economics and Statistics, 1996), and its area in Andhra Pradesh is mostly confined to Kurnool region. However, it can be grown in coastal districts of Andhra Pradesh during post-rainy season. Identification of suitable sunflower varieties/hybrids for this region along with optimum fertilization would pave the way to improve the yields of sunflower.

It is needless to emphasize the importance of hybrids in increasing the productivity of sunflower. Since they are suitable for input intensive agriculture and are superior in their seed filling ability.

Fertilization assumes added importance in sunflower as the crop need intensive growth in a comparatively shorter period which result in the production of a large amount of dry matter (Rao et. al., 1973). Phosphorus is one of the major plant nutrients occupying a key place in fertilization (Tandon, 1987). Because of the key role in vital energy transformation in living tissues phosphorus is rightly called as the "mineral of life" (Goswami and Kamat, 1984). Adequate phosphorus nutrition is one of the important components in improving the filling of seeds in central portion of head in sunflower (Kumar and Basava Raju, 1985).

Responsiveness of sunflower to phosphorus application was reported by Bhowmik et. al. (1994) and Sarkar et. al. (1995).

In view of the above facts and also the emphasis laid on the maximization of edible oilseeds production, there is a need to study the responsiveness of sunflower cultivars to the levels of phosphorus under the agro-climatic conditions of South Coastal Andhra Pradesh as the information available in this aspect is meagre. Hence, the present investigation was under taken at the Agricultural College Farm, Bapatla (Andhra Pradesh) with the following objectives.

1. To find out a suitable sunflower hybrid for the South Coastal region of Andhra Pradesh.

2. To study the effect of levels of phosphorus on growth and yield of sunflower.

3. To study the interaction between the sunflower hybrids and levels of phosphorus.

Review of Literature

CHAPTER - II

REVIEW OF LITERATURE

The literature pertaining to "Response of sunflower cultivars to levels of Phosphorus" is reviewed and presented in this chapter.

2.1 EFFECT OF PHOSPHORUS ON GROWTH PARAMETERS OF SUNFLOWER

2.1.1 Plant Height

Significant increase in plant height was recorded with increased rates of phosphorus from 0 to 50 kg P_2O_5 ha^{-1} (Gaur et. al., 1973). Chaudhary and Paturde (1981) from Akola, Mishra et. al. (1994) from Bhubaneswar reported significant increase in plant height with increase in phosphorus levels upto 60 kg P_2O_5 ha^{-1}. Misra and Avijit Sen (1986) from Varanasi, also reported significant response upto 60 kg P_2O_5 ha^{-1} in increasing plant height and there was no response for further increase in the dose to 90 kg P_2O_5 ha^{-1}.

Several Research workers observed significant increase in plant height with 80 kg P_2O_5 ha^{-1} (Shanthamallaiah et. al., 1977; Dhaka and Agrawal, 1981; Chaniara et. al., 1989 and Kandalkar et. al., 1991) and with 112.5 kg P_2O_5 ha^{-1} (Prabhuraj et. al., 1993) and with 160 kg P_2O_5 ha^{-1} (El-Sayed et. al., 1985).

The results of Singhi and Pacheria (1981) showed that the plant height was not affected significantly due to phosphorus application. Similar results were recorded from trials conducted at Lathur (Directorate of Oilseeds Research, 1988) and Coimbatore (Directorate of Oilseeds Research, 1989).

2.1.2 Stem Girth

Increase in stem girth was noticed with increase in levels of phosphorus from 0 to 60 kg P_2O_5 ha^{-1} on clay loam soils of Kota, Rajasthan (Singhi and Pacheria, 1981). A progressive and significant increase in stem diameter of sunflower with each increment in phosphorus levels upto 90 kg P_2O_5 ha^{-1} was reported by Misra and Avijitsen (1986). El-Sayed et. al. (1985) obtained maximum stem girth with application of 160 kg P_2O_5 ha^{-1}.

Conversely, Chaudhary and Paturde (1981) from Akola reported that stem diameter due to application of phosphorus was not affected by 0, 30 and 60 kg P_2O_5 ha^{-1}. Nagabhushana Rao (1990) working on clay soils of Bapatla found that the stem diameter of sunflower at harvest was not affected with increasing phosphorus levels from 0 to 90 kg P_2O_5 ha^{-1}.

2.1.3 Leaf Area Index

LAI was significantly influenced due to phosphorus application upto 30 kg P_2O_5 ha^{-1} at 20 DAS, flowering and harvest, the increase in LAI was inconsistant with further increase in phosphorus levels (Thomos Varghese et. al., 1976).

A significant increase in LAI at flowering was noted with phosphorus at 40 kg P_2O_5 ha^{-1}, and further increase in phosphorus levels to 80 kg P_2O_5 ha^{-1} reduced the LAI (Bhowmik et. al., 1994). Chaniara et. al. (1989) found that increased rates of phosphorus from 40 to 80 kg P_2O_5 ha^{-1} did not effect the LAI significantly in calcareous soils with medium phosphorus status during *rabi* seasons at Junagadh.

Mishra et. al. (1994) found that LAI at flowering improved significantly with increased levels of phosphorus from 0 to 60 kg P_2O_5 ha^{-1} at Bhubaneswar on sandy loam soils with low available phosphorus. Kandalkar et. al. (1991) working on clayey soils with low available phosphorus (19.52 kg ha^{-1}) also reported increase in LAI with increased rates of phosphorus application from 0 to 80 kg P_2O_5 ha^{-1}.

2.1.4 Dry Matter Production

Bhowmik *et. al.* (1994) obtained significant response in dry matter production in sunflower with application of phosphorus upto 40 kg P_2O_5 ha^{-1}. From a two year study, Adiseshaiah *et. al.* (1978) found significant increase in dry matter upto 45 kg P_2O_5 ha^{-1} in the second year only. Maatouk and El-Latif (1986) recorded maximum dry matter production over control when 46.5 or 93 kg phosphorus as superphosphate ha^{-1} was applied in sandy soils.

The investigations of Misra and Avijitsen (1986) revealed that the dry matter accumulation was significantly increased with increase in levels of phosphorus upto 60 kg P_2O_5 ha^{-1}. They further stated that the dry matter produced at 60 kg P_2O_5 ha^{-1} was statistically at a par with 90 kg P_2O_5 ha^{-1}. The increase in dry matter production upto 60 kg P_2O_5 ha^{-1} was reported by Gawande (1990) and Mishra *et. al.* (1995). Similar trend in dry matter production of sunflower was also reported by Narsi Reddy and Madan Mohan Reddy (1993) in sandy loam soils at Hyderabad.

Kandalkar (1991) from Akola and Khokhani (1991) from Navasari working on clay loams with medium phosphorus status did not find significant response in growth parameters upto 80 and 90 kg P_2O_5 ha^{-1} respectively.

2.1.5 Days to 50% Flowering

Tripathi and Kalra (1981) reported that phosphorus application significantly reduced the days taken to 75% floral bud opening in sunflower grown in summer seasons on sandy loam soils of Meerut. Whereas, Nagabhushana Rao (1990) at Bapatla observed that number of days taken to 50% flowering was not significantly affected due to phosphorus application.

2.2 EFFECT OF PHOSPHORUS ON YIELD ATTRIBUTES OF SUNFLOWER

2.2.1 Head Diameter and Head Weight

A significant increase in head diameter was obtained upto 30 kg P_2O_5 ha^{-1} during *kharif* (Misra and Avijitsen, 1986), upto 45 kg P_2O_5 ha^{-1} during *kharif* (Adiseshaiah *et*. *al*., 1978) and upto 50 kg P_2O_5 ha^{-1} during *rabi* (Jagtap and Sabale, 1994).

Several Research Workers reported increase in head diameter with increase in phosphorus levels upto 60 kg P_2O_5 ha^{-1} (Somasundaram and Iruthayaraj, 1981 and Narsi Reddy and Madan Mohan Reddy, 1993) during *kharif* seasons and (Mishra *et*. *al*., 1994 and Sarkar *et*. *al*., 1995) during *rabi* seasons.

Dhaka and Agrawal (1981) at Kanpur obtained response even upto 80 kg P_2O_5 ha^{-1} during kharif season. Chaniara et. al. (1989) found a significant increase in head diameter with 80 kg P_2O_5 ha^{-1} than 40 and 60 kg P_2O_5 ha^{-1}. The response even upto 112.5 kg P_2O_5 ha^{-1} in increasing the head diameter in soils deficient in available phosphorus was reported by Prabhuraj et. al. (1993).

Application of phosphorus did not significantly increase the head diameter in sunflower grown on clay loam soils (Singh and Kaushal, 1975; Singhi and Pacheria, 1981; Kandalkar et. al., 1991 and Bhowmik et. al., 1994). At Central Arid Zone Research Institute, Jodhpur in sandy loam soils Daulay and Singh (1980) did not find significant response for head diameter to phosphorus application. Chaudhary and Paturde (1981) working on clay soils of Akola also did not observe any improvement in head diameter due to phosphorus application. Similar results were obtained in red sandy loam soils of Coimbatore (Somasundaram and Iruthayaraj, 1981).

Mishra et. al. (1994) stated that increased rates of phosphorus from 0 to 60 kg P_2O_5 ha^{-1} significantly increased the head weight of sunflower in sandyloam soils with low phosphorus status during *rabi* season at Bhubaneswar.

A non-significant increase in head weight in sunflower was observed with increased rates of phosphorus from 0 to 80 kg P_2O_5 ha^{-1} (Kandalkar *et. al.*, 1991).

2.2.2 Number of Filled Seeds per Head and Sterility Percentage

A linear increase in number of filled seeds per head was observed with increase in phosphorus levels from 0 to 50 kg P_2O_5 ha^{-1} (Jagtap and Sabale, 1994) and from 0 to 60 kg P_2O_5 ha^{-1} (Sarkar *et. al.*, 1995). The results of the experiments conducted by Somasundaram and Iruthayaraj (1981) and Narsi Reddy and Madan Mohan Reddy (1993) showed an increase in number of filled seeds per head with increase in phosphorus level upto 60 kg P_2O_5 ha^{-1}, but showed a non-significant reduction trend with further addition of phosphorus upto 90 kg P_2O_5 ha^{-1}.

Adiseshaiah *et. al.* (1978) stated that number of filled seeds per head was increased with increase in phosphorus level, but it was not significant in their first year's trial. While, it was significant in second year. Chaudhary and Paturde (1981) and Chaniara *et. al.* (1989) obtained non-significant response in number of filled seeds per head of sunflower due to phosphorus application on soils having medium available phosphorus.

Singh and Kaushal (1975) and Misra and Avijitsen (1986) reported that sterility percentage of sunflower significantly decreased with increase in phosphorus levels from 0 to 60 kg P_2O_5 ha^{-1}. Narsi Reddy and Madan Mohan Reddy (1993) from Hyderabad stated that phosphorus application had a positive significant effect on sterility percentage. They found decrease in sterility per cent with increase in phosphorus levels from 0 to 90 kg P_2O_5 ha^{-1}.

Conversely, several investigators (Thomas Varghese et. al., 1976; Gupta and Sharma, 1978; Chaudhary and Paturde, 1981 and Chaniara et. al., 1989) found that sterility percentage was not affected significantly due to phosphorus application.

2.2.3 Filled Seed Weight per Head and 1000-Seed Weight

Vikram Singh et. al. (1973) reported a significant increase in filled seed weight per head with 26.4 kg P_2O_5 ha^{-1} than 13.2 kg P_2O_5 ha^{-1}. Chaniara et. al. (1989) and Mishra et. al. (1994) reported significant response in weight of filled seeds per head with application of phosphorus upto 60 kg P_2O_5 ha^{-1}.

At Jodhpur, Daulay and Singh (1980) obtained non-significant response in filled seed weight per head of sunflower due to phosphorus application on soils with low phosphorus status.

Test weight was significantly increased with increase in phosphorus levels from 0 to 30 kg P_2O_5 ha^{-1} (Daulay and Singh, 1980 and Maheswarappa et. al., 1986). Bhowmik et. al. (1994) recorded higher test weight with 40 kg P_2O_5 ha^{-1}. Adiseshaiah et. al. (1978) obtained maximum test weight with 45 kg P_2O_5 ha^{-1}.

The increase in test weight with further increase in phosphorus levels upto 60 kg P_2O_5 ha^{-1} was reported by Singh and Kaushal (1975), Somasundaram and Iruthayaraj (1981), Mishra et. al. (1994) and Sarkar et. al. (1995).

The response in terms of test weight with further increase in phosphorus levels was reported by various other workers, upto 80 kg P_2O_5 (Dhaka and Agrawal, 1981) and upto 90 kg P_2O_5 (Misra and Avijitsen, 1986 and Narsi Reddy and Madan Mohan Reddy, 1993) and upto 120 kg P_2O_5 ha^{-1} (Tarakeswara Rao et. al., 1989).

However, the results of many others (Gupta and Sharma, 1978; Narayanan and Iruthayaraj, 1984; Shelke et. al., 1990; Prabhuraj et. al., 1993 and Sathiyavelu et. al., 1994) revealed that the 1000-seed weight of sunflower did not vary significantly to applied phosphorus. The experimental results from Coimbatore and Lathur (Directorate of Oilseeds Research, 1987 and 1988) also revealed similar trend.

2.3 EFFECT OF PHOSPHORUS ON YIELD

2.3.1 Seed Yield

Phosphorus at 25 kg P_2O_5 ha^{-1} increased the seed yield of sunflower (Gaur et. al., 1989 and Jagtap and Sabale, 1994). There was no significant increase in seed yield due to application of phosphorus @ 30 and 60 kg P_2O_5 ha^{-1} over control, during the two years of experimentation, but in pooled data significant increase in seed yield was noticed with 30 kg P_2O_5 ha^{-1} (Singhi and Pacheria, 1981).

Increase in seed yield with further increase in phosphorus levels upto 40 kg P_2O_5 ha^{-1} was reported by Dhaka and Agrawal (1981), Voinescu et. al. (1986), Bhowmik et. al. (1994) and Mishra et. al. (1995). Similarly Adiseshaiah (1976) recorded a seed yield of 856.4 kg ha^{-1} with 45 kg P_2O_5 ha^{-1} at Tirupathi.

Hiramath *et. al.* (1992) found that application of 50 kg P_2O_5 ha^{-1} significantly increased the seed yield of sunflower. Similarly other Research workers namely Singh and Kaushal (1975) at Jabalpur, Somasundaram and Iruthayaraj (1981) at Bhavanisagar and Coimbatore, Misra and Avijitsen (1986) at Varanasi, Gawande (1990) and Naphade and Naphade (1991) at Akola, Narsi Reddy and Madan Mohan Reddy (1993) at Hyderabad and Mishra *et. al.* (1994) at Bhubaneswar, working on soils with low available phosphorus obtained significantly higher seed yields of sunflower with 60 kg P_2O_5 ha^{-1}.

Increased yield to further higher levels upto 90 kg P_2O_5 ha^{-1} was reported by Vivek *et. al.* (1993) and upto 112.5 kg P_2O_5 ha^{-1} by Prabhuraj *et. al.* (1993) and upto 120 kg P_2O_5 ha^{-1} by Megur *et. al.* (1993).

Conversely, several investigators (Vikram Singh *et. al.*, 1973; Girase *et. al.*, 1977; Singh *et. al.*, 1977; Bhosale *et. al.*, 1979; Chaudhary and Paturde, 1981; Leon *et. al.*, 1985; Chaniara *et. al.*, 1989; Loubser *et. al.*, 1990; Shelke *et. al.*, 1990; Kandalkar *et. al.*, 1991; Sidhu *et. al.*, 1991; Lewis *et. al.*, 1992 and Khokhani *et. al.*, 1993) found that application of phosphorus did not significantly increase the seed yield of sunflower.

From the above review it can be inferred that the response of sunflower to phosphorus application although ranged from 25 to 120 kg P_2O_5 ha^{-1}, many Research workers obtained response between 40 and 60 kg P_2O_5 ha^{-1} in soils with low available phosphorus status. While, many others noticed non responsiveness of sunflower to phosphorus application.

2.3.2 Stalk Yield

Phosphorus at 25 kg P_2O_5 ha^{-1} significantly increased the stalk yield of sunflower at Pune (Jagtap and Sabale, 1994). Mishra et. al. (1995) at Bhubaneswar, on sandy loam soils of low available phosphorus status recorded a significant increase in stover yield with 40 kg P_2O_5 ha^{-1}.

The results of Chaniara et. al. (1989) and Khokhani et. al. (1993) revealed that stalk yield of sunflower was not significantly influenced by phosphorus.

2.3.3 Harvest Index

Nagabhushana Rao (1990) from Bapatla and Mishra et. al. (1995) from Bhubaneswar stated that phosphorus application did not influence the harvest index of sunflower when it was tried with 0, 30, 60 and 90 kg P_2O_5 ha^{-1} and 20, 40 and 60 kg P_2O_5 ha^{-1} respectively.

2.4 EFFECT OF PHOSPHORUS ON OIL CONTENT AND OIL YIELD IN SUNFLOWER

2.4.1 Oil Content

Misra and Avijitsen (1986), Gawande (1990), Narsi Reddy and Madan Mohan Reddy (1993), found that 60 kg P_2O_5 ha^{-1} resulted in higher oil content than lower doses. El-Sayed et. al. (1985) found that phosphorus application upto 160 kg P_2O_5 ha^{-1} in Egypt, resulted in increased oil percentage in sunflower seeds.

On the contrary, several others (Rollier et. al., 1976; Girase et. al., 1977; Chaudhary and Paturde, 1981; Narayanan and Iruthayaraj, 1984; Maatouk and El-Latif, 1986; Maheswarappa et. al., 1986; Gaur et. al., 1989; Kandalkar et. al., 1991 and Sathiyavelu et. al., 1994) reported that phosphorus had no significant effect on the oil content of sunflower.

2.4.2 Oil Yield

The results of Raut and Ghonsikar (1978) revealed that oil yield of sunflower was proportionately increased with the application of phosphorus from 200 to 300 kg ha^{-1}

Conversely, Nagabhushana Rao (1990) reported that oil yield of sunflower was not significantly influenced by phosphorus application.

2.5 EFFECT OF PHOSPHORUS ON P UPTAKE BY SUNFLOWER

Increasing phosphorus levels from 0 to 60 kg P_2O_5 ha^{-1} significantly increased the uptake of phosphorus in plants at knee-high stage, at flower opening and at maturity (Kalra and Tripathi, 1980 and Gawande, 1990). Similarly, a significant increase in phosphorus uptake was recorded with increasing phosphorus levels from 20 to 60 kg P_2O_5 ha^{-1} (Mishra et. al., 1994 and Mishra et. al., 1995).

At Navasari, growing sunflower during rabi on clay soils with medium phosphorus (47 kg P_2O_5 ha^{-1}), the uptake of P in leaf, stalk, and in seed was not significantly affected due to phosphorus application (Khokhani et. al., 1993).

2.6 INTERACTION BETWEEN PHOSPHORUS LEVELS AND SUNFLOWER CULTIVARS ON SEED YIELD OF SUNFLOWER

Cultivation of EC-68414 with 45 kg P_2O_5 ha^{-1} gave maximum seed yield during kharif season at Tirupathi (Adiseshaiah, 1976).

Variety 'Surya' and 60 kg P_2O_5 ha^{-1} was statistically significant combination over other possible combinations (Gawande, 1990).

Naphade and Naphade (1991) working on clay soils of Akola found that the interaction between varieties and phosphorus levels was found to be significant. Varieties 'EC-68414' and 'Morden' responded to phosphorus upto 60 kg P_2O_5 ha^{-1}, whereas 'Surya' responded upto 80 kg P_2O_5 ha^{-1}.

Materials & Methods

CHAPTER - III

MATERIALS AND METHODS

A field experiment entitled "Response of sunflower cultivars to levels of phosphorus in rabi season" was conducted at Agricultural college farm, Bapatla during rabi 1996-'97. The materials used and the methodology followed in the present investigation are presented briefly in this chapter.

3.1 LOCATION

The farm is situated at an altitude of 3 metres above mean sea level at $15^{\circ}84'$ N latitude and $30^{\circ}31'$ E longitude.

3.2 WEATHER CONDITIONS

The Weather data recorded at mateorological observatory of Agricultural College farm, Bapatla during the crop growing season are compared with the decennial average of previous 10 years (1986-1996) (Table 3.1). During the crop growing season the maximum and minimum temperature values are slightly less by about $1^{\circ}C$ in all months except in March where minimum temperature values were less by $2.43^{\circ}C$ as against decennial average of $21.72^{\circ}C$. The entire crop growing season of 1996-'97 was relatively humid compared to the decennial mean.

Table 3.1 Comparison between the weather that prevailed during the crop season of 1996-'97 with respect to the decennial mean

Month	Maximum temperature (°C)		Minimum temperature (°C)		Relative Humidity (%)		Rainfall (mm)	
	Decennial mean	1996-'97 mean	Decennial mean	1996-'97 mean	Decennial mean	1996-'97 mean	Decennial total	1996-'97 total
December	29.17	28.82	18.16	17.86	75.5	80.3	291.5	4.4
January	29.37	28.28	17.22	16.95	77.8	78.2	184.9	22.3
February	30.54	30.17	18.84	18.51	75.9	80.7	144.0	-
March	32.47	32.07	21.72	19.29	73.8	78.3	98.7	-
Mean	30.38	29.83	18.98	18.15	75.8	79.4	71.91	26.7

3.3 SOIL ANALYSIS

The soils of College Farm are coastal sands. In these soils the clay soil from the nearby village was transported and applied on the surface upto depth of 30cm. The soil samples were collected from 0-15 cm depth before layout of the experiment and a composite sample was made through quartering. The composite soil sample was analysed for physico-chemical properties which are presented in table 3.2.

The mechanical analysis of the soil indicated that the texture was clay loam. The chemical analysis of the soil indicated that the soil was moderately alkaline in reaction, low in available nitrogen, medium in available Phosphorus and high in available Potassium.

3.4 CROPPING HISTORY OF THE EXPERIMENTAL FIELD

The Experimental field has been in cultivation for many years. The cropping history, however, for the three consecutive preceding years is given below.

Year	Season	Crop
1994-'95	Kharif	Sorghum & Cowpea
	Rabi	Coriander
1995-'96	Kharif	Sunnhemp
	Rabi	Bengalgram
1996-'97	Kharif	Sunnhemp
	Rabi	Present study

Table 3.2 Physico-chemical properties of the experimental soil

Property	Value	Method adopted
A. Mechanical Analysis		
Sand (%)	42	Bouyoucos hydrometer
Silt (%)	18	method (Piper, 1966)
Clay (%)	40	
B. Chemical Analysis		
Soil P^H (1:2.5 soil water suspension)	8.5	Jackson (1973)
EC (d S m^{-1}) (1:2 soil water suspension)	0.45	Richards (1954)
Available N (Kg ha^{-1})	242	Alkaline permanganate method (Subbiah and Asija, 1956)
Available P (Kg ha^{-1})	10.3	Olsen's method (Olsen et. al., 1954)
Available K (Kg ha^{-1})	391.7	Flame photometer (Jackson, 1973)

3.5 EXPERIMENTAL DETAILS

The Experimental treatments consisted of four sunflower hybrids assigned to main plots and four phosphorus levels assigned to sub-plots. The Experimental details are furnished below.

Main plot treatments : Hybrids - 4

V_1 APSH - 11

V_2 KBSH - 1

V_3 MSFH - 8

V_4 MEGA - 363

Sub-plot treatments : Phosphorus levels - 4

P_o No phosphorus

P_1 30 Kg P_2O_5 ha^{-1}

P_2 60 Kg P_2O_5 ha^{-1}

P_3 90 Kg P_2O_5 ha^{-1}

The Experiment was laid out in a split-plot design. The layout plan is depicted in fig. 3.1.

Replications : 3

Spacing : 60 x 30 cm

Plot size : Gross plot 4.8 x 3.6 m

Net plot 2.4 x 3.0 m

R_1	V_4P_3	V_4P_0	V_2P_2	V_2P_1	V_3P_2	V_3P_3	V_1P_2	V_1P_1
	V_4P_1	V_4P_2	V_2P_0	V_2P_3	V_3P_1	V_3P_0	V_1P_3	V_1P_0
	IRRIGATION CHANNEL							
R_2	V_1P_0	V_1P_3	V_3P_3	V_3P_0	V_2P_2	V_2P_1	V_4P_2	V_4P_3
	V_1P_1	V_1P_2	V_3P_1	V_3P_2	V_2P_3	V_2P_0	V_4P_1	V_4P_0
	IRRIGATION CHANNEL							
R_3	V_2P_1	V_2P_3	V_4P_2	V_4P_0	V_1P_3	V_1P_2	V_3P_0	V_3P_1
	V_2P_0	V_2P_2	V_4P_1	V_4P_3	V_1P_1	V_1P_0	V_3P_2	V_3P_3

TREATMENTS:

Main Plots (Hybrids):

- V_1 APSH-11
- V_2 KBSH-1
- V_3 MSFH-8
- V_4 MEGA-363

Sub-Plots (Phosphorus levels)

- P_0 No phosphorus
- P_1 30 kg P_2O_5 ha^{-1}
- P_2 60 kg P_2O_5 ha^{-1}
- P_3 90 kg P_2O_5 ha^{-1}

Design: Split-Plot

Replications: 3

Plot size: Gross plot
4.8 x 3.6 m

Net plot
2.4 x 3.0 m

Crop: SUNFLOWER

Fig.3.1 Lay out plan of the Experimental Plot

3.6 VARIETAL DESCRIPTION

The important characters of hybrids are given below.

3.6.1 APSH-11 (Andhra Pradesh Sunflower Hybrid-11)

It is a cross between 7-1 A x RHA 271 with a maturity period of 90-100 days and days to 50% flowering is 55 days. Average height of the plant is 120-145 cm. It contains 40-42 per cent oil in seeds. Yield potential is 10-15 q ha^{-1} which can be doubled with irrigation.

3.6.2 KBSH-1 (Karnataka Bangalore Sunflower Hybrid-1)

It is a cross between CMS - 234 A x 6D - 1. Average height of the plant is 130-160 cm. Crop duration is 95-100 days and comes to 50% flowering with in 55-60 days. It contains 38-40 per cent oil in seeds. Yield potential is 12-16 q ha^{-1}.

3.6.3 MSFH-8 (Mahyco Sunflower Hybrid-8)

A Sunflower hybrid developed by Mahyco Hybrid Seeds Company Ltd., Maharastra. Average plant height is 190-200 cm. It comes to maturity in 92-94 days with days to 50% flowering is 62-64 days. The 100-seed weight is

4-5 g. It contains 42-44 per cent oil in seeds. The yield potential is 32-33 q ha^{-1} under irrigation with excellent seed setting.

3.6.4 MEGA-363

A superior sunflower hybrid developed by Omega Agro Seeds (India) Ltd., in technical colobration with Agro seeds Pty. Ltd., Australia. The average plant height is 160-165 cm. The crop duration is 95-110 days with days to 50% flowering is 65 days. The oil content of seeds is 45 per cent. The yield potential is 19-38 q ha^{-1} depending upon soil and recommended cultural practices. The 100-seed weight is 5-6 g.

3.7 CULTIVATION DETAILS

The calender of operations is furnished in Appendix-A.

3.7.1 Field Preparation

The Experimental field was prepared by working with tractor drawn cultivator twice. The land was levelled and the plots were laid out as per the layout plan with irrigation channels.

3.7.2 **Seeds and Sowing**

Healthy and mature seeds of the hybrids under test were pre-soaked in water for about 12 hours and shade dried and were treated with thiram @ 2-3 g Kg^{-1} seed. The treated seeds were dried in shade for two hours and sown at a depth of 3-4 cm on 13th December, 1996 by adopting a spacing of 60 x 30 cm.

3.7.3 **Fertilizers**

A uniform dose of 40 Kg N and 30 Kg K_2O ha^{-1} through urea and muriate of potash along with entire P_2O_5 as per the treatments through Diammonium phosphate (18-46-0) was supplied at the time of sowing. The nitrogen content in Diammonium phosphate was taken into account and the rest of N was compensated through urea. Another 40 kg N ha^{-1} was applied in two equal splits one at 30 DAS and second at 50 DAS through urea to each plot making the total N applied to 80 kg ha^{-1}.

3.7.4 **Thinning and Gap Filling**

Thinning and gap filling were done 10 DAS by leaving one healthy seedling per hill.

3.7.5 **Irrigation**

A light irrigation was given immediately to all the plots after sowing for better germination. Later, the crop was irrigated as and when required during the crop growth period.

3.7.6 Interculture Operations

Weeds present between and within the rows were removed by hand weeding at 25 DAS.

3.7.7 Plant Protection

Tobacco caterpillar (*Spodoptera litura*) was occasionally observed but their intensity of infestation was below the economic threshold level. The pest was checked by spraying N P V @ 500 LE ha^{-1}, further the caterpillars were hand picked by employing women labour.

3.7.8 Hand Pollination

When 50 per cent of the flowers were opened in the field, hand pollination was done on alternate days for two weeks in the morning hours (8 A.M. to 11 A.M.).

3.7.9 Harvesting

The crop was harvested when the back of heads turned to lemon yellow and the bottom leaves started drying and withering.

3.8 COLLECTION OF EXPERIMENTAL DATA

For recording continuous observations ten plants were labelled at random from the net plot. For recording observations involving destructive sampling two plants were uprooted each time from second row earmarked for the purpose. For this purpose three rows on one side and one row on other side from each plot were taken as border rows. At harvest the seed and stalk yields of the ten labelled plants were added to the net plot yield for calculating the final yields per hectare.

3.8.1 Pre-Harvest Observations

3.8.1.1 **Plant Height (cm).** Plant height was recorded from the ground level to the top most growing point of the plant at 30, 60 DAS and at harvest.

3.8.1.2 **Stem Girth (cm).** Stem girth was calculated with the help of vernier calipers by measuring the diameter of the stem at the base of the plant.

3.8.1.3 **Leaf Area Index.** For each sampling all the leaves were seperated fresh and leaf area was measured with Δ T - leaf area meter and Leaf Area Index (LAI) was calculated using the formula.

$$LAI = \frac{\text{Leaf Area}}{\text{Ground Area}}$$

3.8.1.4 **Dry Matter Production (g m^{-2}).** The plants obtained from destructive sampling row at 30, 60 DAS and at harvest were dried under shade first and then oven dried at 60^{o}C to a constant weight and the dry weights were recorded.

3.8.1.5 **Days to 50% Flowering.** The crop in a treatment was considered to have flowered when 50 per cent of its population came to flowering. The total number of days required from sowing to 50 per cent flowering was considered as days to 50 per cent flowering.

3.9 POST-HARVEST OBSERVATIONS

3.9.1 Diameter of Head (cm)

Diameter of the capitulum for the ten labelled plants in each treatment was measured and average of ten plants was taken to get mean diameter of head.

3.9.2 Weight of Head (g)

Dried heads of the ten labelled plants in each treatment were weighed and average of ten plants was taken to get mean weight of head.

3.9.3 Number of Filled Seeds per Head

The number of filled seeds were counted for ten heads in each treatment and average number of filled seeds per head was calculated.

3.9.4 Sterility Percentage

Sterility percentage was worked out from the number of unfilled seeds to the total number of seeds in the capitulum.

$$\text{Sterility Percentage} = \frac{\text{unfilled seeds head}^{-1}}{\text{Total seeds head}^{-1}} \times 100$$

3.9.5 Weight of Filled Seeds per Head (g)

Weight of filled seeds collected from mature heads of ten labelled plants was recorded and the average weight of filled seeds per head was worked out.

3.9.6 1000-Seed Weight (g)

Weight of thousand seeds selected randomly in each treatment was recorded and expressed as test weight in grams.

3.9.7 Seed Yield (kg ha^{-1})

Weight of the seeds obtained from net plot area of each treatment including ten tagged plants was recorded and yield per hectare was calculated.

3.9.8 Stalk Yield (kg ha^{-1})

Dry weight of the above ground parts of the plants excluding economic part from the net plot including ten labelled plants was recorded after thorough sun drying and expressed as stalk yield.

3.9.9 Harvest Index (HI)

Harvest Index was calculated from each treatment using the formula as given below.

$$\text{Harvest Index (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

3.10 CHEMICAL ANALYSIS

3.10.1 Oil Content (%)

Oil content of the seeds for each treatment was estimated by Nuclear Magnetic Resonance (NMR) method as suggested by Tiwary et. al. (1974) by taking 12 g of seed as a sample for oil content and the per cent of oil content in the seed was recorded directly.

3.10.2 Oil Yield (kg ha^{-1})

The oil yield was worked out based on seed yield per hectare and corresponding oil content (%).

3.10.3 Phosphorus Uptake (Kg ha^{-1})

Phosphorus content in dry matter at 30 and 60 DAS was estimated. At harvest these contents were estimated in seed and stalk separately.

For the estimation of Phosphorus content Vanadomolybdo phosphoric yellow colour method as given by Jackson (1973) was adopted. The phosphorus uptake in Kg ha^{-1} was calculated by multiplying the per cent P concentration with the weight of dry matter.

3.11 STATISTICAL ANALYSIS

All the data recorded during the course of experimentation were subjected to statistical analysis as outlined by Sundara Rajan et. al. (1972) for split-plot design. Statistical significance was tested with the help of "F-test" at 5.0 per cent level of significance. The difference among treatment means for each parameter was tested using the calculated critical difference (C.D) at 5 per cent level of probability.

Results

General View of the Experimental Field

CHAPTER - IV

RESULTS

A field experiment entitled "Response of sunflower cultivars to levels of phosphorus in rabi season", was conducted during rabi 1996-'97 at Agricultural College Farm, Bapatla. The data on growth parameters, yield attributes, yield, oil content, oil yield and phosphorus uptake together with statistical interpretation are furnished in this chapter.

4.1 GROWTH PARAMETERS

4.1.1 **Plant Height (cm)**

4.1.1.1 **At 30 DAS.** The data on plant height recorded at 30 DAS is furnished in the table 4.1.

It is seen from the data that plant height at 30 DAS was not influenced significantly due to hybrids, phosphorus levels and their interaction.

4.1.1.2 **At 60 DAS.** Data pertaining to plant height at 60 DAS as affected by different treatments are presented in table 4.2.

Hybrids and phosphorus levels failed to exhibit significant influence on plant height at 60 DAS. However, interaction between hybrids and phosphorus levels was found to be significant.

Table 4.1 Plant height (cm) at 30 DAS as influenced by hybrids and phosphorus levels in sunflower

Treatment	Plant height (cm)
HYBRIDS:	
APSH-11	54.6
KBSH-1	47.1
MSFH-8	54.2
MEGA-363	50.9
SEm $\pm$	1.75
CD (0.05)	NS
CV%	11.76
PHOSPHORUS LEVELS: ($kg\ P_2O_5\ ha^{-1}$)	
0	49.6
30	50.6
60	53.1
90	53.4
SEm $\pm$	1.66
CD (0.05)	NS
CV%	11.13

Table 4.2 Plant height (cm) at 60 DAS as influenced by hybrids and phosphorus levels in sunflower

Hybrids	Phosphorus levels (kg P_2O_5 ha^{-1})				Mean
	0	30	60	90	
APSH-11	151.4	146.1	150.9	151.4	149.9
KBSH-1	130.2	147.4	144.0	127.5	137.3
MSFH-8	168.9	161.1	162.2	161.1	163.3
MEGA-363	145.7	137.2	135.9	149.0	141.9
Mean	149.0	147.9	148.3	147.2	

	SEm$\pm$	CD (0.05)	CV%
HYBRIDS	5.42	NS	12.66
PHOSPHORUS LEVELS	2.26	NS	5.29
HYBRIDS x PHOSPHORUS LEVELS			
Between phosphorus levels at the same hybrid	4.52	13.20	
Between hybrids at the same or different level of phosphorus	6.68	21.88	

From the perusal of the data, it was evident that all the sunflower hybrids except KBSH-1 failed to respond significantly to any dose of phosphorus. KBSH-1 responded significantly upto 30 kg P_2O_5 ha^{-1}. MSFH-8 produced significantly taller plants than MEGA-363 at 30 and 60 kg P_2O_5 ha^{-1} but it was comparable with KBSH-1 and APSH-11. Maximum plant height of 168.9 cm was recorded with MSFH-8 at 0 kg P_2O_5 ha^{-1} and minimum plant height of 127.5 cm was recorded with KBSH-1 at 90 kg P_2O_5 ha^{-1}.

4.1.1.3 **At harvest.** The data furnished in the table 4.3 indicated that plant height at harvest was significantly different among sunflower hybrids.

MSFH-8 produced significantly taller plants than MEGA-363 and KBSH-1 but it was at a par with APSH-11. The hybrids, APSH-11, KBSH-1 and MEGA-363 were at a par with each other in respect to plant height.

Levels of phosphorus had no significant effect on plant height at harvest.

Interaction effects between hybrids and phosphorus levels were statistically significant.

MSFH-8 produced significantly taller plants over others at 0 kg P_2O_5 ha^{-1}. At 30 and 60 kg P_2O_5 levels the

Table 4.3 Plant height (cm) at harvest as influenced by hybrids and phosphorus levels in sunflower

Hybrids	Phosphorus levels (kg P_2O_5 ha^{-1})				Mean
	0	30	60	90	
APSH-11	155.4	147.1	153.2	152.7	152.1
KBSH-1	134.7	147.7	147.2	128.7	139.6
MSFH-8	178.1	163.8	168.6	169.2	169.9
MEGA-363	151.4	138.8	138.1	153.3	145.4
Mean	154.9	149.4	151.8	151.0	

	SEm±	CD (0.05)	CV%
HYBRIDS	5.41	18.72	12.35
PHOSPHORUS LEVELS	2.354	NS	5.37
HYBRIDS x PHOSPHORUS LEVELS			
Between phosphorus levels at the same hybrid	4.71	13.74	
Between hybrids at the same or different level of phosphorus	6.77	22.11	

same hybrid produced significantly taller plants over MEGA-363 but it was comparable with the remaining hybrids (APSH-11 and KBSH-1) at these levels of phosphorus. Maximum plant height (178.1 cm) was recorded with MSFH-8 when no phosphorus was applied. Minimum plant height (128.7 cm) was recorded with KBSH-1 when 90 kg P_2O_5 was applied.

4.1.2 **Stem Girth (cm)**

4.1.2.1 **At 30 DAS.** The data pertaining to stem girth was statistically analysed and furnished in table 4.4.

Maximum stem girth (5.57 cm) was recorded with MEGA-363 which was statistically significant over MSFH-8, KBSH-1 and APSH-11. The latter three hybrids did not differ significantly among themselves.

Significant differences were not observed in this aspect either due to phosphorus levels or their interaction with sunflower hybrids.

4.1.2.2 **At 60 DAS.** MEGA-363 recorded maximum stem girth of 8.12 cm which was superior to MSFH-8, KBSH-1 and APSH-11. The latter three hybrids were at a par with each other (Table 4.5). Various phosphorus levels had no significant effect on stem girth at 60 DAS (Table 4.5).

Table 4.4 Stem girth (cm) at 30 DAS as influenced by hybrids and phosphorus levels in sunflower

Treatment	Stem girth (cm)
HYBRIDS:	
APSH-11	4.70
KBSH-1	4.43
MSFH-8	4.85
MEGA-363	5.57
SEm $\pm$	0.17
CD (0.05)	0.57
CV%	11.58
PHOSPHORUS LEVELS: ($kg\ P_2O_5\ ha^{-1}$)	
0	5.02
30	4.85
60	4.98
90	4.99
SEm $\pm$	0.13
CD (0.05)	NS
CV%	8.98

Table 4.5 Stem girth (cm) at 60 DAS and at harvest as influenced by hybrids and phosphorus levels in sunflower

Hybrids	Phosphorus levels (kg P_2O_5 ha^{-1})									
	At 60 DAS				Mean	At harvest				Mean
	0	30	60	90		0	30	60	90	
APSH-11	5.74	5.83	5.86	6.30	5.93	5.63	5.48	5.64	5.95	5.67
KBSH-1	5.61	6.36	6.42	5.74	6.03	5.44	6.08	6.10	5.44	5.76
MSFH-8	6.86	6.66	6.80	6.78	6.77	6.16	6.18	6.32	6.43	6.27
MEGA-363	8.27	8.14	7.28	8.77	8.12	7.32	6.98	6.25	7.46	7.00
Mean	6.62	6.75	6.59	6.90		6.14	6.18	6.08	6.32	

	At 60 DAS			At harvest		
	SEm±	CD (0.05)	CV%	SEm±	CD (0.05)	CV%
HYBRIDS	0.31	1.06	15.90	0.28	NS	16.09
PHOSPHORUS LEVELS	0.12	NS	6.29	0.09	NS	5.19
HYBRIDSxPHOSPHORUS LEVELS						
Between phosphorus levels at the same hybrid	0.24	0.71		0.18	0.54	
Between hybrids at the same or different level of phosphorus	0.37	1.23		0.32	1.09	

Interaction between sunflower hybrids and phosphorus levels was statistically significant.

At all the levels of phosphorus MEGA-363 recorded maximum stem girth over all other hybrids, but at 60 kg P_2O_5 level it was comparable with MSFH-8 and KBSH-1. Maximum stem girth of 8.77 cm was obtained with the combination of MEGA-363 and 90 kg P_2O_5 ha^{-1} and minimum stem girth of 5.61 cm was obtained with the combination of KBSH-1 and 0 kg P_2O_5 ha^{-1} (Table 4.5).

4.1.2.3 **At harvest.** Data in table 4.5 revealed that both sunflower hybrids and phosphorus levels failed to exhibit a significant influence on stem girth at harvest.

At 0 kg P_2O_5 ha^{-1}, MEGA-363 recorded maximum stem girth over all other hybrids, but, at 30 kg P_2O_5 ha^{-1} it was comparable with MSFH-8 and KBSH-1 and at 90 kg P_2O_5 ha^{-1} it was comparable with MSFH-8 only. MEGA-363 with 90 kg P_2O_5 ha^{-1} recorded maximum stem girth of 7.46 cm and minimum stem girth of 5.44 cm was obtained with KBSH-1 when no phosphorus was applied (Table 4.5).

4.1.3 **Leaf Area Index (LAI)**

The data presented in table 4.6 in general revealed that LAI was low at the initial stages (30 DAS)

Table 4.6 LAI at different stages of crop growth as influenced by hybrids and phosphorus levels in sunflower

Treatment	Days after sowing		At harvest
	30	60	
HYBRIDS:			
APSH-11	0.954	2.803	0.996
KBSH-1	0.955	2.420	0.817
MSFH-8	1.073	2.845	0.477
MEGA-363	1.057	2.450	0.910
SEm $\pm$	0.03	0.11	0.05
CD (0.05)	NS	NS	0.16
CV%	11.97	14.49	20.26
PHOSPHORUS LEVELS: (kg P_2O_5 ha^{-1})			
0	0.768	2.584	0.643
30	1.154	2.867	0.880
60	1.055	2.409	0.895
90	1.062	2.658	0.782
SEm $\pm$	0.06	0.13	0.07
CD (0.05)	0.18	NS	NS
CV%	21.37	17.13	30.29

and reached a peak by 60 DAS followed by a sharp decrease towards the maturity.

LAI was not influenced due to hybrids at 30 and 60 DAS, but at harvest it was significantly different among sunflower hybrids.

At harvest, LAI value of APSH-11 (0.996) was significantly higher over KBSH-1 (0.817) and MSFH-8 (0.477) but it was at a par with MEGA-363 (0.910). Inturn KBSH-1 and MSFH-8 differed significantly with each other in respect of LAI at harvest.

Various phosphorus levels failed to respond in increasing the LAI at all stages except at 30 DAS. Maximum LAI (1.154) was recorded with 30 kg P_2O_5 ha^{-1} which was significantly superior to 0 kg P_2O_5 ha^{-1} but at a par with 60 and 90 kg P_2O_5 ha^{-1}.

Interaction effects between sunflower hybrids and phosphorus levels were not significant at all stages under study.

4.1.4 **Dry Matter accumulation**

Data pertaining to dry matter accumulation is presented in the table 4.7, Fig.4.1. It was evident from the data that a steep increase in dry matter accumulation

Table 4.7 Dry matter accumulation (g m^{-2}) at different stages of crop growth as influenced by hybrids and phosphorus levels in sunflower

Treatment	Days after sowing 30	60	At harvest
HYBRIDS:			
APSH-11	51.41	375.2	479.2
KBSH-1	52.83	335.6	449.5
MSFH-8	59.49	362.9	692.5
MEGA-363	53.32	310.5	694.2
SEm $\pm$	2.27	18.06	19.64
CD (0.05)	NS	NS	67.90
CV%	14.53	18.08	11.75
PHOSPHORUS LEVELS: (kg P_2O_5 ha^{-1})			
0	42.81	345.3	578.8
30	57.21	363.9	579.2
60	55.10	339.1	570.1
90	61.93	335.8	587.2
SEm $\pm$	4.09	24.43	23.46
CD (0.05)	11.94	NS	NS
CV%	26.12	24.45	14.04

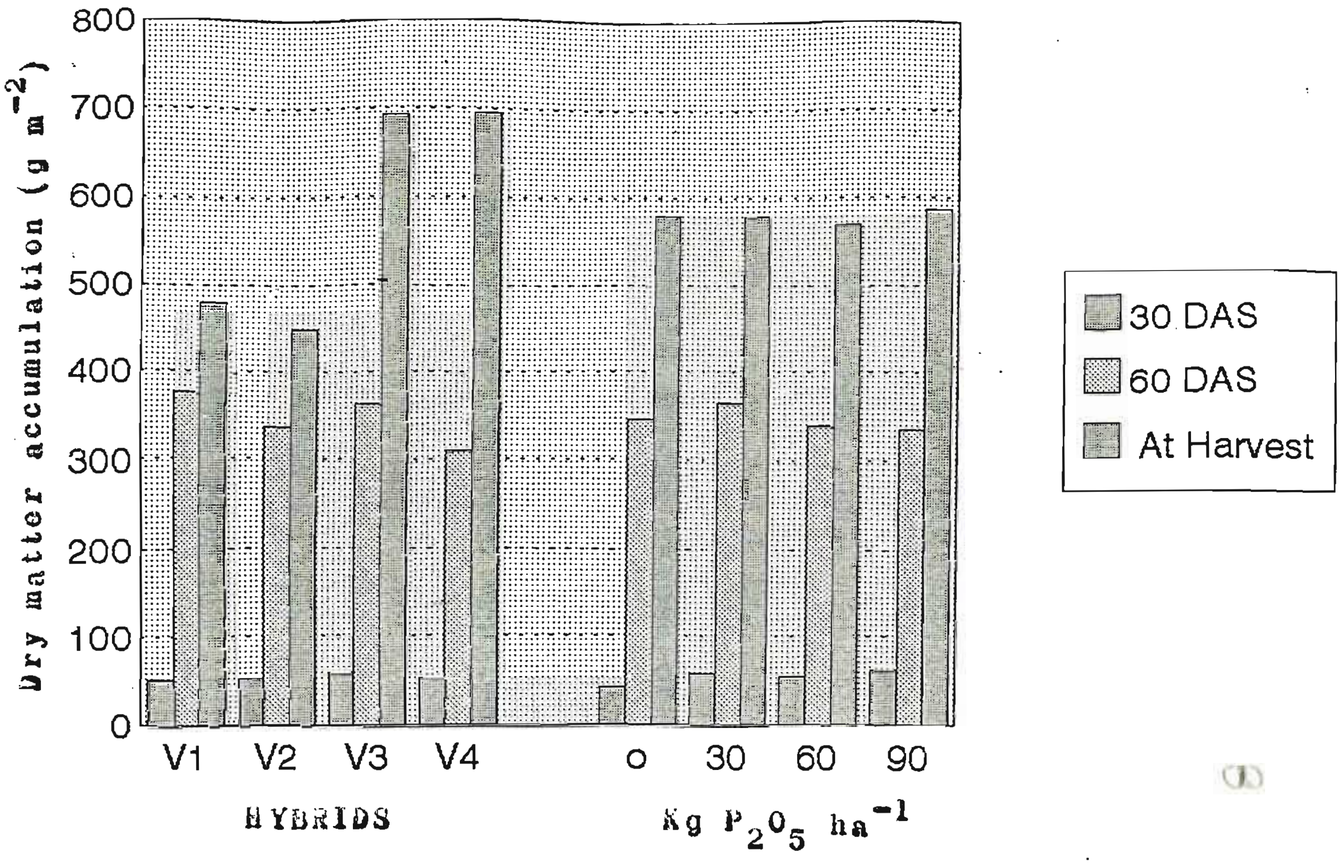

Fig. 4.1: Dry matter accumulation (g m-²) at different stages of crop growth as influenced by hybrids and Phosphorus levels.

(9.73 g m^{-2} day^{-1}) was recorded between 30-60 DAS followed by between 60 DAS-at harvest with a rate of 7.76 g m^{-2} day^{-1}.

There was no significant difference among sunflower hybrids at all stages studied except at harvest, where sunflower hybrids differed significantly.

Among different hybrids, MEGA-363 and MSFH-8 produced significantly higher dry matter over APSH-11 and KBSH-1, the former two and latter two hybrids were found to be at a par with each other.

Levels of phosphorus failed to exhibit significant effect in this regard at all stages of crop growth except at 30 DAS.

In early stage (30 DAS) application of 30 kg P_2O_5 ha^{-1} significantly increased the dry matter over no phosphorus application, and further increase in the phosphorus levels upto 90 kg did not increase the dry matter production significantly.

4.1.5 Days to 50% Flowering

On scrutiny of the data presented in table 4.8, it was revealed that the number of days taken to 50% flowering differed significantly due to sunflower hybrids

Table 4.8 Days to 50% flowering as influenced by hybrids and phosphorus levels in sunflower

Treatment	Days to 50% flowering
HYBRIDS:	
APSH-11	55.3
KBSH-1	55.9
MSFH-8	60.1
MEGA-363	56.3
SEm $\pm$	0.75
CD (0.05)	2.59
CV%	4.56
PHOSPHORUS LEVELS:	
(kg P_2O_5 ha^{-1})	
0	57.8
30	56.8
60	56.5
90	56.5
SEm $\pm$	0.27
CD (0.05)	0.79
CV%	1.64

and phosphorus levels. Interaction effects of these two factors were found to be non-significant.

Among different sunflower hybrids MSFH-8 came to 50% flowering late by 4 to 5 days than all other hybrids. APSH-11, KBSH-1 and MEGA-363 were at a par with each other in this regard.

Phosphorus application caused a significant effect with 1 to 1.3 days earliness compared to control. The different phosphorus levels did not differ significantly among themselves.

4.2 YIELD ATTRIBUTES

4.2.1 Head Diameter (cm)

Phosphorus application and the interaction between sunflower hybrids and phosphorus levels did not significantly influence the head diameter. Whereas, sunflower hybrids differed significantly in the head diameter (Table 4.9).

Hybrids, MEGA-363 and APSH-11 recorded higher head diameter than MSFH-8 and KBSH-1. Between the latter two hybrids, MSFH-8 recorded higher value for head diameter than KBSH-1.

Table 4.9 Head diameter (cm) and head weight (g) as influenced by hybrids and phosphorus levels in sunflower

Treatment	Head diameter (cm)	Head weight (g)
HYBRIDS:		
APSH-11	15.98	57.25
KBSH-1	13.70	48.75
MSFH-8	14.85	68.00
MEGA-363	16.20	77.08
SEm ±	0.24	3.30
CD (0.05)	0.82	11.43
CV%	5.38	18.22
PHOSPHORUS LEVELS: ($kg\ P_2O_5\ ha^{-1}$)		
0	15.06	58.33
30	14.89	60.33
60	15.37	65.58
90	15.40	66.84
SEm ±	0.23	2.60
CD (0.05)	NS	NS
CV%	5.35	14.34

4.2.2 Head Weight (g)

Similar to head diameter, head weight did not differ significantly due to phosphorus levels and their interaction with sunflower hybrids (Table 4.9). However, there was significant difference in head weight among hybrids. Maximum head weight (77.08 g) was obtained with MEGA-363 which was significantly superior to APSH-11 and KBSH-1 but it was at a par with MSFH-8 (68.00 g). Inturn MSFH-8 was at a par with APSH-11 and recorded higher head weight over KBSH-1. The difference in head weight between APSH-11 and KBSH-1 was not significant.

4.2.3 Number of Filled Seeds per Head

The data furnished in the table 4.10 and depicted in Fig.4.2 indicated that number of filled seeds per head was significantly different in different sunflower hybrids.

Among different hybrids, more number of filled seeds per head was recorded in MSFH-8 (838.08), which was significantly higher than APSH-11 (680.08), MEGA-363 (676.41) and KBSH-1 (437.33). APSH-11 and MEGA-363 were at a par and produced more number of filled seeds per head than KBSH-1.

Table 4.10 Number of filled seeds per head and sterility percentage as influenced by hybrids and phosphorus levels in sunflower

Treatment	Number of filled seeds per head	Sterility percentage
HYBRIDS:		
APSH-11	680.08	25.67
KBSH-1	437.33	26.94
MSFH-8	838.08	17.34
MEGA-363	676.41	25.21
SEm $\pm$	41.32	1.05
CD (0.05)	143.01	3.65
CV%	21.75	15.34
PHOSPHORUS LEVELS:		
(kg P_2O_5 ha^{-1})		
0	645.25	24.58
30	636.00	26.06
60	666.91	23.59
90	683.75	20.93
SEm $\pm$	36.18	2.09
CD (0.05)	NS	NS
CV%	19.04	30.56

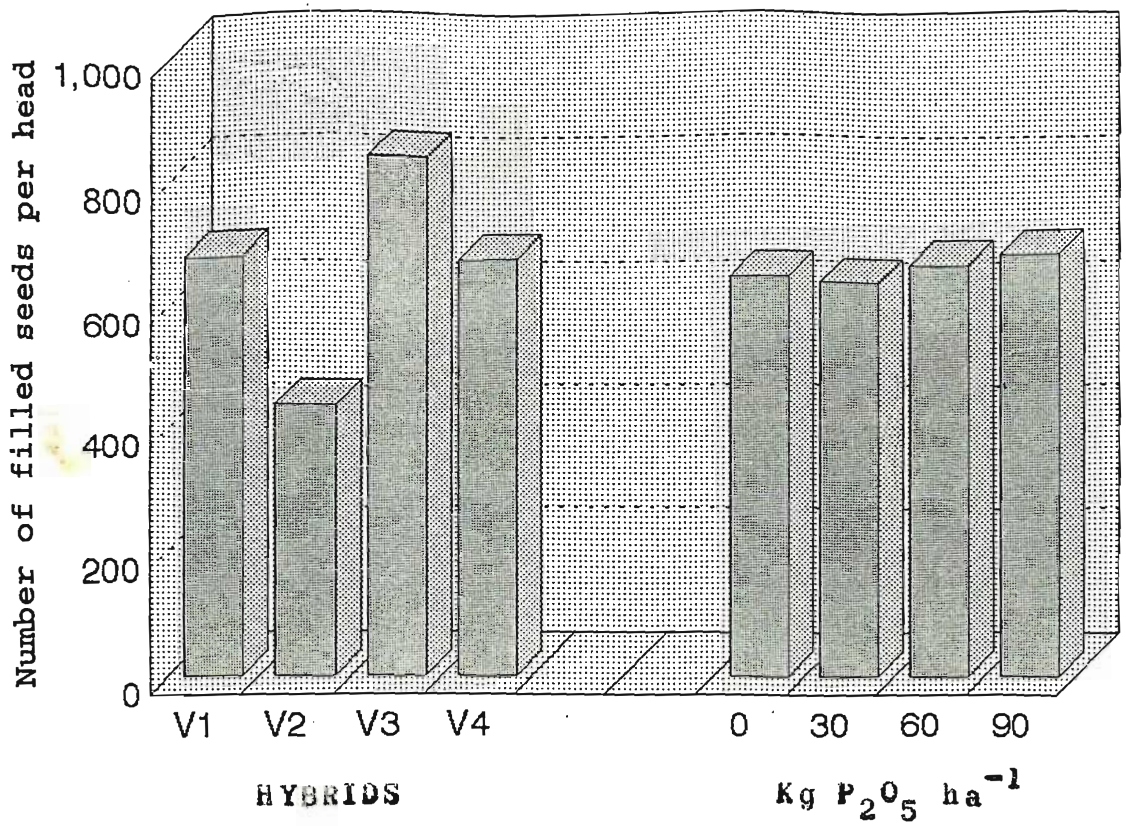

Fig. 4.2 : Number of filled seeds per head as influenced by hybrids and phosphorus levels.

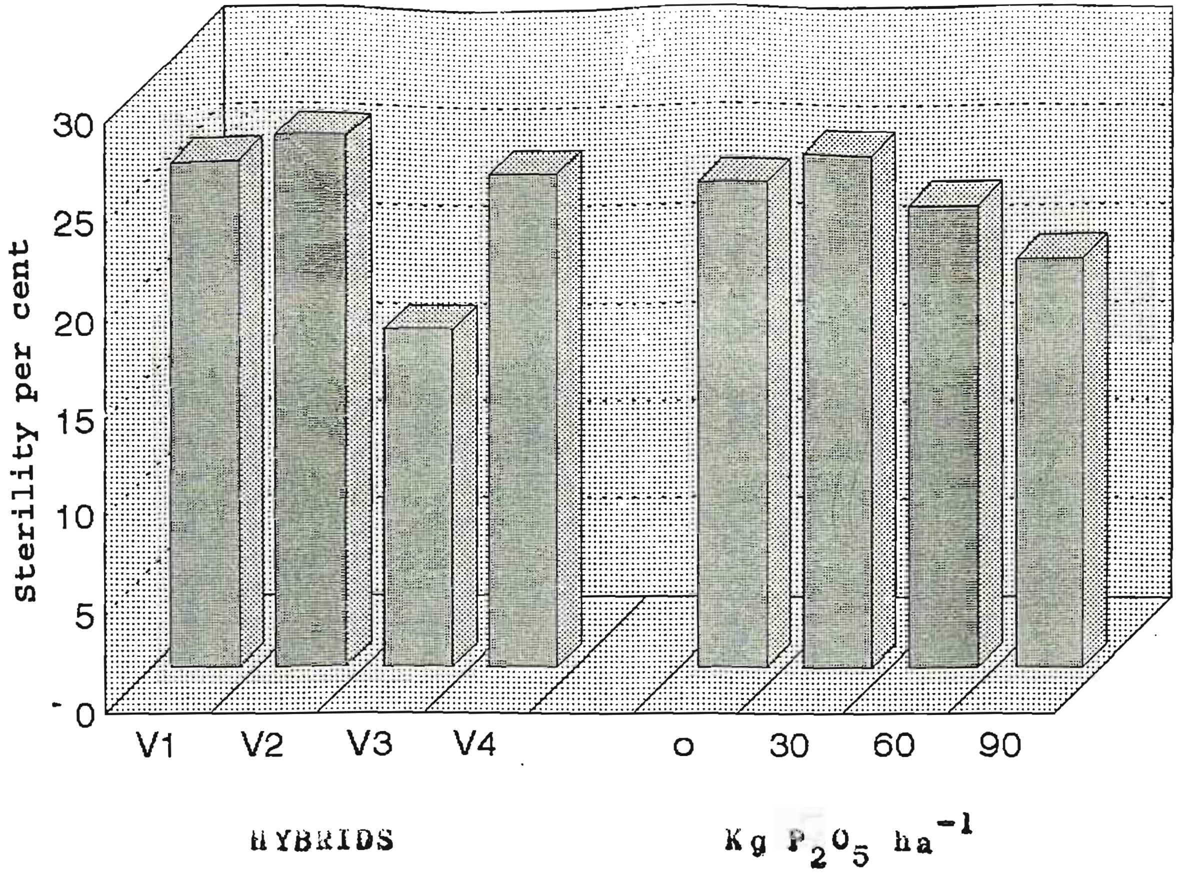

Fig. 4.3 : Sterility percentage as influenced by hybrids and phosphorus levels.

Levels of phosphorus did not influence the number of filled seeds per head. Interaction between hybrids and phosphorus levels was found to be non-significant.

4.2.4 **Sterility Percentage**

Data on sterility percentage presented in table 4.10, Fig.4.3 indicated that the sterility percentage varied significantly between sunflower hybrids.

The sterility percentage (17.34) was lowest in MSFH-8 which was significantly lower than all other hybrids viz., MEGA-363, APSH-11 and KBSH-1. Differences in sterility percentage among the latter three hybrids were not significant.

Variations in sterility percentage due to phosphorus levels and the interaction between hybrids and phosphorus levels were not significant.

4.2.5 **Weight of Filled Seeds per Head (g)**

Data pertaining to weight of filled seeds per head of different sunflower hybrids as affected by different phosphorus levels are furnished in table 4.11, Fig.4.4.

The weight of filled seeds per head was maximum (42.95 g) in MSFH-8 which was more than MEGA-363

Table 4.11 Filled seed weight per head (g) and test weight (g) as influenced by hybrids and phosphorus levels in sunflower

Treatment	Filled seed weight per head (g)	Test weight (g) (1000-seed wt.)
HYBRIDS:		
APSH-11	30.49	49.47
KBSH-1	23.13	56.36
MSFH-8	42.95	50.90
MEGA-363	32.13	51.74
SEm ±	0.86	1.10
CD (0.05)	2.99	3.81
CV%	9.33	11.96
PHOSPHORUS LEVELS: ($kg\ P_2O_5\ ha^{-1}$)		
0	31.97	50.92
30	31.70	53.00
60	31.98	52.72
90	33.05	51.83
SEm ±	1.19	1.80
CD (0.05)	NS	NS
CV%	12.82	19.59

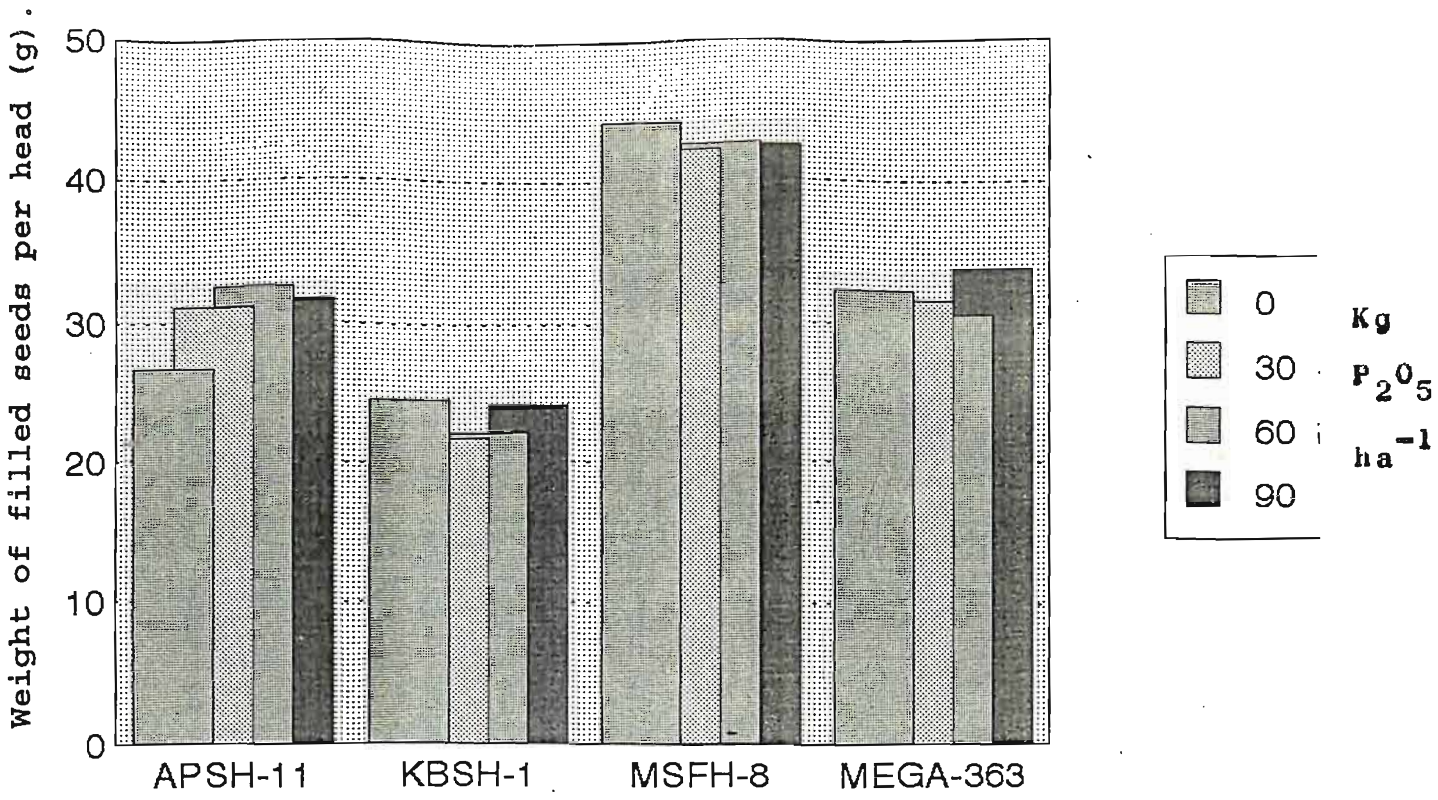

Fig. 4.4 : Weight of filled seeds per head (g) as influenced by various phosphorus levels in different sunflower hybrids.

(32.13 g), APSH-11 (30.49 g) and KBSH-1 (23.13 g). The increase in filled seed weight in MSFH-8 was 33.6, 40.8 and 85.6 per cent over MEGA-363, APSH-11 and KBSH-1, respectively. The difference in filled seed weight per head due to MEGA-363 and APSH-11 was not significant but both of them were significantly superior to KBSH-1.

Effects of different doses of phosphorus and interaction between sunflower hybrids and phosphorus levels were not significant.

4.2.6 **Test Weight (g)**

The 1000-seed weight of hybrid 'KBSH-1' (56.36 g) was significantly higher than MEGA-363 (51.74 g), MSFH-8 (50.90 g) and APSH-11 (49.47 g) hybrids. However, the difference in test weight among MEGA-363, MSFH-8 and APSH-11 was not discernible (Table 4.11).

Neither the effect of phosphorus nor the interaction between sunflower hybrids and phosphorus levels was significant (Table 4.11).

4.3 YIELD

4.3.1 **Seed Yield (kg ha^{-1})**

The data on seed yield as influenced by different treatments is presented in the table 4.12 and the trends

Table 4.12 Seed yield (kg ha^{-1}), stalk yield (kg ha^{-1}) and harvest index (%) as influenced by hybrids and phosphorus levels in sunflower

Treatment	Seed yield (kg ha^{-1})	Stalk yield (kg ha^{-1})	Harvest index (%)
HYBRIDS:			
APSH-11	1514	3281	31.50
KBSH-1	1150	3346	26.00
MSFH-8	2174	4752	31.40
MEGA-363	1642	5302	23.50
SEm $\pm$	56	189	0.78
CD (0.05)	194	656	2.70
CV%	11.97	15.74	7.16
PHOSPHORUS LEVELS: (kg P_2O_5 ha^{-1})			
0	1611	4181	28.20
30	1597	4197	27.50
60	1603	4099	28.10
90	1669	4205	28.60
SEm $\pm$	88	172	0.72
CD (0.05)	NS	NS	NS
CV%	18.96	14.30	6.57

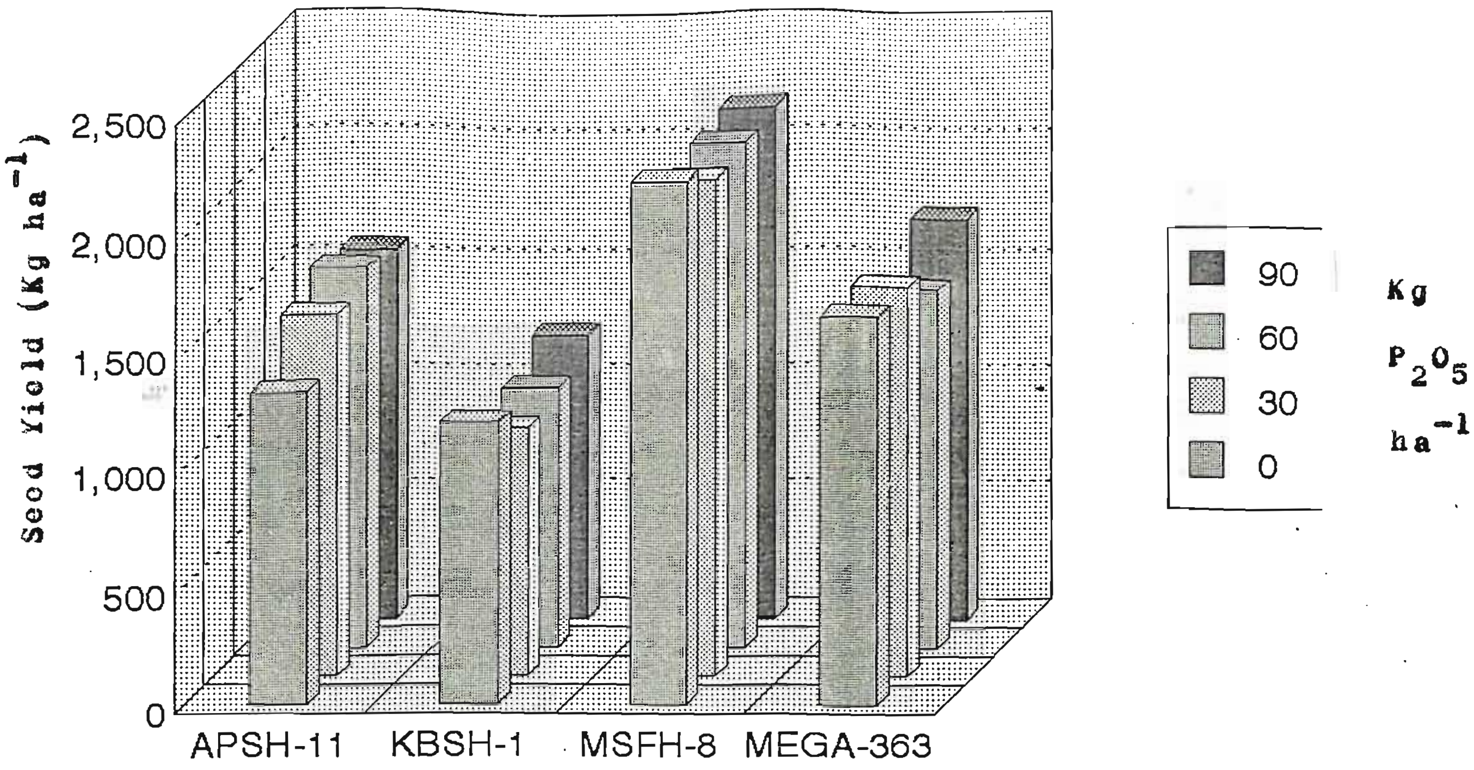

Fig.4.5 : **Seed yield (kg ha^{-1}) as influenced by various phosphorus levels in different sunflower hybrids.**

are shown in Fig.4.5. On scrutiny of the data it was revealed that seed yield differed significantly between the sunflower hybrids.

Among the four sunflower hybrids tried, MSFH-8 (2174 kg ha^{-1}) yielded significantly more seed per hectare, than MEGA-363 (1642 kg ha^{-1}), APSH-11 (1514 kg ha^{-1}), and KBSH-1 (1150 kg ha^{-1}). The increase in seed yield due to MSFH-8 was 32.4, 43.6 and 89.0 per cent over MEGA-363, APSH-11 and KBSH-1, respectively. MEGA-363 and APSH-11 were at a par and gave significantly higher seed yields than KBSH-1.

Different levels of phosphorus from 0 to 90 kg per hectare had no significant effect on seed yield.

Interaction effects between sunflower hybrids and phosphorus levels were found to be non-significant.

4.3.2 Stalk Yield (kg ha^{-1})

In the present trial, application of phosphorus had no significant influence on stalk yield (Table 4.12).

Higher stalk yield was obtained from MEGA-363 (5302 kg ha^{-1}) which was at a par with MSFH-8 (4572 kg ha^{-1}) and both of them recorded significantly higher stalk yield than KBSH-1 (3346 kg ha^{-1}) and APSH-11 (3281 kg ha^{-1}). There was no significant difference in stalk yield between KBSH-1 and APSH-11.

Interaction effects between hybrids and phosphorus levels failed to reach the level of significance.

4.3.3 Harvest Index (%)

Harvest Index was not affected by phosphorus levels (Table 4.12). Interaction between hybrids and phosphorus levels was also not significant. Hybrids differed significantly in harvest index.

Both MSFH-8 and APSH-11 recorded higher harvest index values than KBSH-1 and MEGA-363 with non-significant differences between them. The latter two hybrids did not differ significantly with respect to harvest index.

4.4 OIL CONTENT (%) AND OIL YIELD (kg ha^{-1})

Data pertaining to oil content and oil yield as affected by different treatments are summarised in table 4.13 and depicted in Fig.4.6 and 4.7, respectively.

The results revealed that the oil content in seeds of MSFH-8 hybrid was highest (41.3%) as against 38.5 per cent in MEGA-363, 35.9 per cent in APSH-11 and 34.6 per

Table 4.13 Oil content (%) and oil yield (kg ha^{-1}) as influenced by hybrids and phosphorus levels in sunflower

Treatment	Oil content (%)	Oil yield (kg ha^{-1})
HYBRIDS:		
APSH-11	35.90	544.1
KBSH-1	34.60	399.0
MSFH-8	41.30	899.4
MEGA-363	38.50	633.0
SEm $\pm$	0.19	25.19
CD (0.05)	0.66	87.17
CV%	1.28	14.09
PHOSPHORUS LEVELS: (kg P_2O_5 ha^{-1})		
0	37.20	609.8
30	37.60	610.6
60	38.10	619.7
90	37.50	635.3
SEm $\pm$	0.32	35.60
CD (0.05)	NS	NS
CV%	2.11	19.93

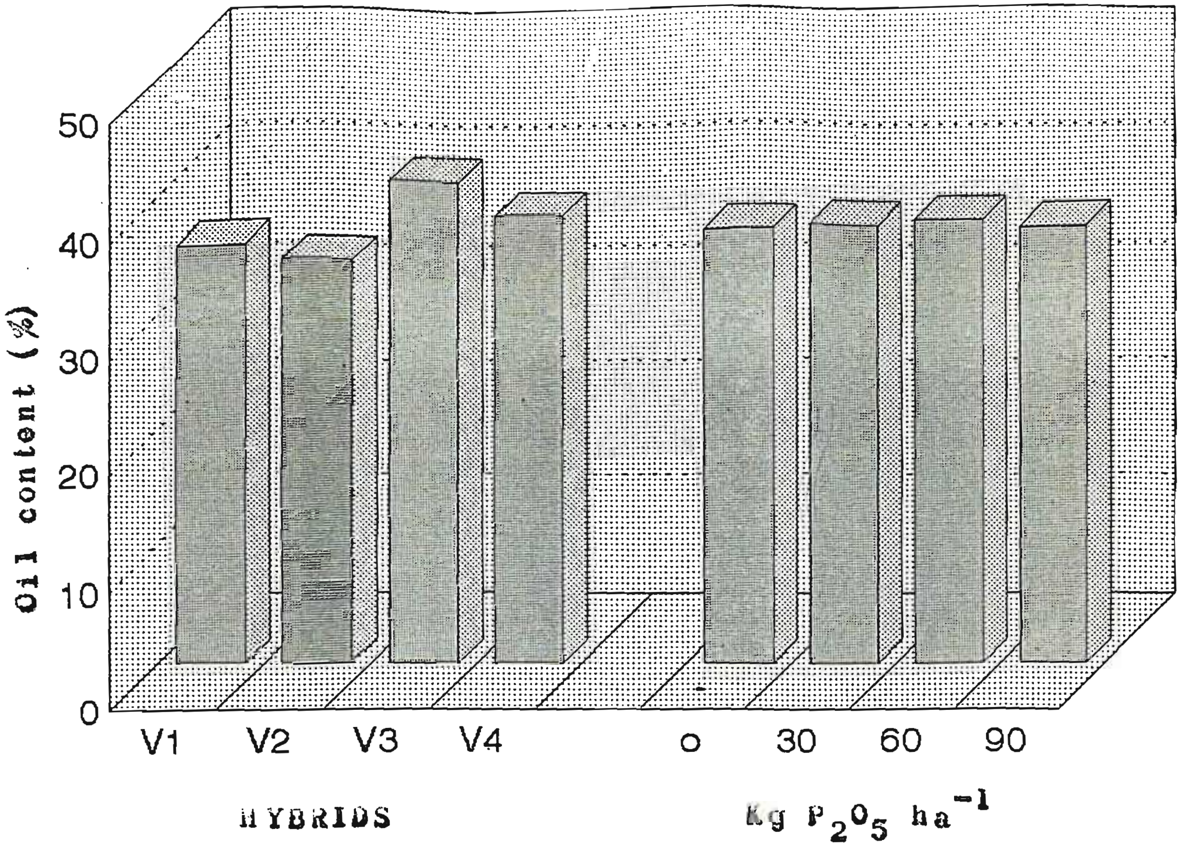

Fig.4.6 : Oil content (%) as influenced by hybrids and phosphorus levels.

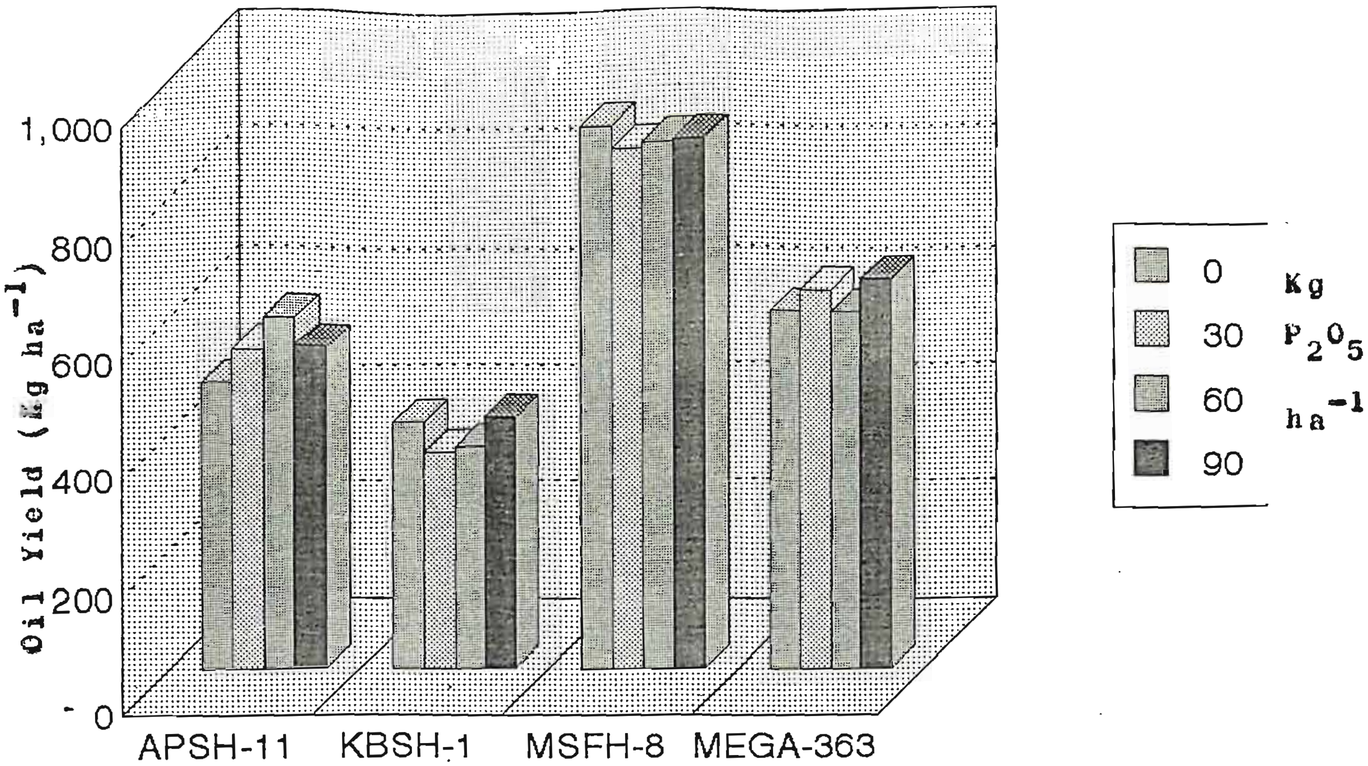

Fig. 4.7 : Oil yield (kg ha^{-1}) as influenced by various phosphorus levels in different sunflower hybrids.

cent in KBSH-1. The oil content in the latter three hybrids differed significantly among themselves.

MSFH-8 recorded highest oil yield of 899.4 kg ha^{-1} which was significantly superior to MEGA-363 (633.0 kg ha^{-1}), APSH-11 (544.1 kg ha^{-1}) and KBSH-1 (399.0 kg ha^{-1}). The increase in oil yield due to MSFH-8 was 42.1, 65.3 and 125.4 per cent over MEGA-363, APSH-11 and KBSH-1, respectively. MEGA-363 inturn gave higher oil yield than APSH-11 and KBSH-1. APSH-11 recorded higher oil yield than KBSH-1.

Variations in oil content and oil yield due to different phosphorus levels and their interaction with sunflower hybrids were not significant.

4.5 UPTAKE OF PHOSPHORUS AT DIFFERENT STAGES OF CROP GROWTH

4.5.1 Phosphorus Uptake at 30 DAS

Application of 30 kg P_2O_5 ha^{-1} resulted in significantly higher uptake of phosphorus than no phosphorus application at 30 DAS, further increase in phosphorus level although increased the uptake but was not upto the level of significance (Table 4.14).

Neither the sunflower hybrids nor their interaction with phosphorus levels was significant on phosphorus uptake.

Table 4.14 Phosphorus uptake (kg ha^{-1}) at 30 and 60 DAS as influenced by hybrids and phosphorus levels in sunflower

Treatment	P uptake (kg ha^{-1})	
	At 30 DAS	At 60 DAS
HYBRIDS:		
APSH-11	2.57	19.12
KBSH-1	2.78	17.84
MSFH-8	2.89	17.45
MEGA-363	3.01	15.46
SEm $\pm$	0.13	1.04
CD (0.05)	NS	NS
CV%	15.94	20.66
PHOSPHORUS LEVELS: (kg P_2O_5 ha^{-1})		
0	2.10	16.88
30	2.77	19.59
60	3.08	16.09
90	3.31	17.32
SEm $\pm$	0.21	1.37
CD (0.05)	0.63	NS
CV%	26.46	27.19

4.5.2 Phosphorus Uptake at 60 DAS

Data on phosphorus uptake at 60 DAS is furnished in Table 4.14. None of the effects under study could significantly influence the P uptake at 60 DAS.

4.5.3 Phosphorus Uptake by Seed

From the data presented in table 4.15, it could be seen that the uptake was significantly influenced by sunflower hybrids.

Among different sunflower hybrids, higher uptake by seed was recorded in MSFH-8 (12.79 kg ha^{-1}) and was significantly superior to MEGA-363 (9.88 kg ha^{-1}), APSH-11 (9.83 kg ha^{-1}) and KBSH-1 (7.86 kg ha^{-1}). Inturn MEGA-363 and APSH-11 were at a par and gave significantly higher uptake of phosphorus than KBSH-1.

Phosphorus levels had no significant effect on P uptake by seed. There was no significant interaction between sunflower hybrids and phosphorus levels on phosphorus uptake by seed.

4.5.4 Phosphorus Uptake by Stalk

It was evident from the table 4.15, that phosphorus uptake in stalks of sunflower varied significantly due to hybrids.

Table 4.15 Phosphorus uptake (kg ha^{-1}) by seed and stalk as influenced by hybrids and phosphorus levels in sunflower

Treatment	P uptake (kg ha^{-1})	
	Seed	Stalk
HYBRIDS:		
APSH-11	9.83	10.24
KBSH-1	7.86	10.47
MSFH-8	12.79	11.42
MEGA-363	9.88	12.22
SEm $\pm$	0.24	0.23
CD (0.05)	0.83	0.81
CV%	8.23	7.32
PHOSPHORUS LEVELS: (kg P_2O_5 ha^{-1})		
0	9.22	10.72
30	10.02	11.14
60	10.38	11.22
90	10.73	11.28
SEm $\pm$	0.47	0.19
CD (0.05)	NS	NS
CV%	16.10	5.81

MEGA-363 recorded higher uptake values of phosphorus by stalk (12.22 kg ha^{-1}) and was comparable with MSFH-8 (11.42 kg ha^{-1}). Both of these hybrids were significantly better than KBSH-1 (10.47 kg ha^{-1}) and APSH-11 (10.24 kg ha^{-1}), the latter two hybrids were at a par with each other.

There was no significant effect on phosphorus uptake by stalk due to different levels of this nutrient. Interaction between sunflower hybrids and phosphorus levels on phosphorus uptake by stalk was not significant.

Discussion

CHAPTER - V

DISCUSSION

The experimental findings have been presented in detail in the preceding chapter and an attempt has been made here to evaluate and explain the important results recorded in the course of present investigation in terms of cause and effect relationship, in the light of pertinent literature.

5.1 GROWTH PARAMETERS

Sunflower hybrid MSFH-8 recorded higher plant height at harvest than MEGA-363 and KBSH-1, however it was at a par with APSH-11 (Table 4.3). This might be due to difference in genetic makeup of the hybrids. This hybrid right from early stages had better growth compared to other hybrids and finally resulted in higher plant height. Further, this hybrid being grown in different regions of Andhra Pradesh appears to be highly adoptable to different situations which might have contributed to perform better over others. Stem girth at 30 and 60 DAS was maximum with MEGA-363 and was significantly superior to MSFH-8, KBSH-1 and APSH-11 (Table 4.4 and 4.5). Hybrids differed in stem girth morphologically with one another. Among different hybrids APSH-11 and MEGA-363 recorded higher LAI vlaues at harvest than KBSH-1 and MSFH-8 (Table 4.6). This was due to less leaf senescence in former hybrids than latter hybrids. Both MEGA-363 and MSFH-8 produced maximum dry matter over APSH-11 and KBSH-1 at harvest (Table 4.7). Maximum dry matter accumulation in MEGA-363 could be due to more LAI, and in MSFH-8 could be due to more plant height. Flowering is the expression of commencement of reproductive phase. In the present study, APSH-11, KBSH-1 and MEGA-363 came to 50 per cent flowering earlier by 4-5 days than MSFH-8 (Table 4.8) as they are of short duration compared to MSFH-8.

Application of phosphorus failed to express a significant influence on plant height (Table 4.1, 4.2 and 4.3). Phosphorus is more associated with reproductive phase rather than the vegetative phase. Venkata Rao and Govinda Rajan (1956) found that phosphorus expressed a decisively, beneficial influence on the formation of grain as against purely vegetative growth. The experimental results of Directorate of Oilseeds Research (1988 and 1989) and Singhi and Pacheria (1981) also showed non-significant response in plant height to added phosphorus in sunflower.

Stem girth was not significantly increased due to phosphorus application (Table 4.4 and 4.5). These findings are in agreement with the observations of Chaudhary and Paturde (1981) and Nagabhushana Rao (1990).

During 'the early stages of the crop growth (30 DAS) application of 30 kg P_2O_5 ha^{-1} significantly influenced both the LAI and dry matter production over control (Table 4.6 and 4.7). This is perhaps due to the fact that in initial stages of crop growth, root contact with soil P is less because of less root spread, thereby P absorbed by roots may not be sufficient for vigorous growth of sunflower in no phosphorus plots, which removed only 2.10 kg ha^{-1} of P at 30 DAS. Wherein P applied plots, P concentration in soil solution generally increased, thereby the uptake of P increased to 3.05 kg ha^{-1} which might have helped in significant increase in LAI and dry matter production at 30 DAS. These results are in accordance with the observations of Thomas Varghese <u>et</u>. <u>al</u>. (1976) who reported that the application of 30 kg P_2O_5 ha^{-1} significantly increased the LAI at 20 DAS. It is further noted that the influence of phosphorus on LAI during the remaining stages of crop growth were only marginal. These findings are in contrast to the observations of Thomas Varghese <u>et</u>. <u>al</u>. (1976) who reported significant influence of phosphorus on later stages of crop growth also.

LAI and dry matter accumulation recorded during later stages (60 DAS and harvest) of crop growth was not significantly influenced due to application of phosphorus (Table 4.6 and 4.7). These observations are in concurrence with the findings of Adiseshaiah _et_. _al_. (1978). Such a non-significant effect of P on LAI and dry matter accumulation with advancement of growth may be due to increase in soil P availability in control plots (where P was not applied) due to root exudates which causes increase in P solubilisation. Root exudation of amino-acids and reducing sugars was greater for plants grown in P-deficit soils than P-treated soils (Graham _et_. _al_., 1981) and these root exudates may solubilize soil P in rhizosphere (Sumio Itoh and Barber, 1983). Further a slight decrease in pH of experimental soil (8.5) due to rhizosphere acidification may increase the P availability. Rape seed plants grown in soil deficient in P, would be supplied with adequate P due to acidification effect of rhizosphere (Hedly _et_. _al_., 1971), acidification of the rhizosphere would be instrumental in the mobilization of ions such as phosphate (Riley and Barber, 1971). Moorby _et_. _al_. (1988) also mentioned that when rape seed plants were grown in P-deficient soil a decrease in the P concentration in rhizosphere soil solution was associated during the first two weeks with an increase in rhizosphere pH, thereafter, this relationship was reversed. The changes in rhizosphere, pH was related to the cation/anion uptake ratio, which increased in the older plants. Similar responses in cation/anion uptake ratio and rhizosphere acidification have been found in P-deficient sunflower plants (Hoffland et. al., 1989). The other reason could be that under irrigated conditions the availability of P may be increased due to release of soil native P. At later stages of crop growth the increased root surface area had a greater accessibility to native soil P. The experimental soil contains 40 per cent of clay in first 30 cm depth of soil which might have decreased the availability of added P due to more fixation. Tisdale et. al. (1993) mentioned that soils containing large quantities of clay will fix more of applied P. The high clay content and higher pH (8.5) values of the present experimental site might have favoured higher fixation of applied P, resulting in no difference in the LAI, and dry matter accumulation at later stages of crop growth between the phosphorus levels. Soils with pH greater than 7 cause precipitation of added P which results in the decreased availability of added P to the plants in P-treated plots (Tisdale et. al., 1993).

Various phosphorus levels (30, 60 and 90 kg P_2O_5 ha^{-1}) significantly advanced the days taken to 50 per cent flowering in all sunflower hybrids by 1 to 1.3 days over control (Table 4.8). Similar results were also reported by Tripathi and Kalra (1981) who found that application of phosphorus significantly reduced the days taken to various developmental stages in sunflower.

Interaction between hybrids and phosphorus levels was found to influence the plant height and stem girth at 60 DAS and at harvest. Both at 60 DAS and harvest, MSFH-8 recorded maximum plant height without phosphorus (Table 4.2 and 4.3). This is probably due to the better absorption of native soil phosphorus under irrigated conditions by this hybrid compared to others, the stem girth was maximum in MEGA-363 with 90 kg P_2O_5 ha^{-1} and the stem girth was minimum in KBSH-1 without phosphorus application (Table 4.5). MEGA-363 could able to utilize applied phosphorus more compared to others, which resulted in the production of stout stems.

5.2 YIELD ATTRIBUTES

MEGA-363 recorded maximum head diameter and was comparable with APSH-11 but both hybrids were superior to MSFH-8 and KBSH-1 (Table 4.9). Production of big capitulum by MEGA-363 and APSH-11 might be responsible for the production of large sized heads. Maximum head weight was obtained with MEGA-363 which was significantly superior to APSH-11 and KBSH-1 but it was at a par with MSFH-8 (Table 4.9). The higher head weight in MEGA-363, might be due to higher head diameter and in MSFH-8, was mainly due to more number of filled seeds per head. MSFH-8 recorded significantly more number of filled seeds per head (838.08) compared to other hybrids viz., APSH-11 (680.08), MEGA-363 (676.41) and KBSH-1 (437.33) (Table 4.10). This might be due to proper filling of the seeds from periphery to central portions of the head, and efficient translocation of the assimilates from source to sink. Sterility percentage was lowest in MSFH-8 (17.34) than MEGA-363, APSH-11 and KBSH-1 (25.94) (Table 4.10). The weight of filled seeds per head was maximum with MSFH-8 and it was significantly superior to MEGA-363, APSH-11 and KBSH-1 (Table 4.11). The higher number of filled seeds per head might have contributed to higher filled seed weight per head. KBSH-1 recorded more test weight than the remaining hybrids (Table 4.11). The higher test weight in KBSH-1 might be due to less number of filled seeds per head (437.33) as against 838.08 number of filled seeds per head in MSFH-8, with less competition among the filled seeds, resulting in bold seeds and thus accounting for higher test weight.

Phosphorus application could not exhibit a significant effect on head diameter (Table 4.9). These results are in conformity with the findings of Singh and Kaushal (1975), Daulay and Singh (1980), Singhi and Pacheria (1981), Kandalkar _et_. _al_. (1991) and Bhowmik _et_. _al_. (1994). Similar to head diameter head weight was not appreciably influenced due to phosphorus application (Table 4.9). Kandalkar _et_. _al_. (1991) also reported similar results. The effect of phosphorus on number of filled seeds per head was not significant (Table 4.10). These results are in accordance with the reports of Chaudhary and Paturde (1981) and Chaniara _et_. _al_. (1989). Phosphorus application did not significantly influence the sterility percentage (Table 4.10). Similar non-significant response to phosphorus on percentage of unfilled seeds was also reported by Thomas Varghese _et_. _al_. (1976), Gupta and Sharma (1978), Chaudhary and Paturde (1981) and Chaniara _et_. _al_. (1989). The weight of filled seeds and test weight was not significantly influenced by phosphorus application (Table 4.11). Similar results for weight of filled seeds was reported by Daulay and Singh (1980) and for test weight by Gupta and Sharma (1978), Narayanan and Iruthayaraj (1984), Directorate of Oilseeds Research (1987 and 1988), Shelke _et_. _al_. (1990), Prabhuraj _et_. _al_. (1993)

and Sathiyavelu et. al. (1994). Since applied phosphorus failed to exhibit any improvement in growth parameters, the yield attributes were also not influenced by phosphorus application.

Interaction between hybrids and phosphorus levels was not significant on any yield attributes (Table 4.9, 4.10 and 4.11).

5.3 **YIELD**

The seed yield of MSFH-8 (2174 kg ha^{-1}) was significantly higher than MEGA-363, (1642 kg ha^{-1}), ASPH-11 (1514 kg ha^{-1}) and KBSH-1 (1150 kg ha^{-1}) (Table 4.12). More number of filled seeds per head, higher filled seed weight per head, and lower sterility percentage helped the MSFH-8 to produce highest seed yield than other hybrids. A perusal of the data on stalk yield (Table 4.12) of different sunflower hybrids revealed that stalk yield of MEGA-363 and MSFH-8 was higher which was mainly due to more dry matter production by these hybrids than others. The highest harvest index values were recorded by MSFH-8 and APSH-11 (Table 4.12) than other hybrids.

Seed yield was not significantly influenced by any level of the phosphorus (Table 4.12). The present findings are in agreement with the results of Vikram Singh et. al. (1973), Girase et. al. (1977), Singh et. al. (1977), Bhosale et. al. (1979), Chaudhary and Paturde (1981), Singhi and Pacheria (1981), Leon et. al. (1985), Chaniara et. al. (1989), Loubser et. al. (1990), Shelke et. al. (1990), Kandalkar et. al. (1991), Sidhu et. al. (1991), Lewis et. al. (1992) and Khokhani et. al. (1993). The lack of response might be due to the presence of sufficient quantities of available phosphorus in the soil (10.3 kg ha^{-1}) and better utilization of this phosphorus by the crop for its growth and development (Singhi and Pacharia, 1981). Rao et. al. (1984) also mentioned that the difference in the abilities of crops to utilize soil and fertilizer P could be largely due to variations in their root properties and in the present experiment, the hybrids tried did not show varied response to phosphorus application which removed relatively higher quantities of native P because of their extensive root systems. Sunflower crop was able to use the residual P applied to the previous crops (Sidhu et. al., 1991).

The other reasons could be that the possibility of release of more native P under irrigated conditions as in present situation. Increased yields from irrigation without phosphorus application are largely at the expense of soil P (Tandon, 1987). Application of nitrogen along with irrigation increased the removal of soil P by 36 per cent in case of wheat (Vig and Singh, 1983), 83-136 per cent in case of Barley (Varma et. al., 1976) and 60 per cent in case of safflower (Singh and Singh, 1980). In the present experiment the crop was raised under irrigation with adequate nitrogen supply which might have helped for removal of higher quantities of P from the soil. Further it might be due to higher availability of soil P due to solubilization by root exudates. Root exudation of amino-acids and reducing sugars was greater for plants grown in P-deficit soils than P-treated soils (Graham et. al., 1981). The root exudates may solubilize P in the rhizosphere soil, thereby P concentration in soil solution may be increased even without phosphorus application (Sumio Itoh and Barber, 1983). Hedly et. al. (1983) had shown that rape seed plants grown in soil, would acidify the soil if deprived of an adequate supply of P. Such acidification of the rhizosphere was suggested to be instrumental in the mobilization of ions such as phosphate (Riley and Barber, 1971). In the present experiment the soil pH of 8.5, might have been decreased due to root exudates and increased the availability of P as the crop growth is advanced.

Phosphorus had no significant effect on the stalk yield of sunflower (Table 4.12). The same reasons which explained for seed yield may also be applicable to stalk yield. The non-significant effect of phosphorus on stalk yield was also reported by Chaniara et. al. (1989) and Khokhani et. al. (1993). Harvest index was not affected due to phosphorus (Table 4.12). Similar results were reported by Nagabhushana Rao (1990) and Mishra et. al. (1995).

Interaction between hybrids and phosphorus levels was not significant with respect to seed yield, stalk yield and HI (Table 4.12).

5.4 OIL CONTENT AND OIL YIELD

MSFH-8 recorded more oil content (41.30%) and higher oil yield (899.4 kg ha^{-1}) than the remaining hybrids MEGA-363, APSH-11 and KBSH-1 (Table 4.13). Oil content is mostly a genetical character wherein variation among the hybrids could be expected. Higher oil yield in MSFH-8 was primarly due to higher seed yield. Since oil yield is a product of oil content and seed yield.

Phosphorus application did not exhibit its superiority in influencing the oil content and oil yield in sunflower (Table 4.13). The present findings for oil content are in conformity with those of Rollier et. al. (1976), Girase et. al. (1977), Chaudhary and Paturde (1981), Maatouk and El-latif (1986), Maheswarappa et. al. (1986), Gaur et. al. (1989), Kandalkar et. al. (1991) and Sathiyavelu et. al. (1994) and for oil yield are in accordance with Nagabhushana Rao (1990).

Interaction effect between sunflower hybrids and phosphorus levels was also not significant in terms of oil content and oil yield (Table 4.13).

5.5 PHOSPHORUS UPTAKE AT DIFFERENT STAGES OF CROP GROWTH

P uptake by seed was higher in MSFH-8 over other hybrids (Table 4.15). This might be due to higher seed yield of this hybrid than others. MEGA-363 and MSFH-8 recorded maximum P uptake by stalk (Table 4.15). The reason could be the higher stalk yield of these hybrids than that of KBSH-1 and APSH-11.

During the early stages of crop growth (30 DAS) only lower dose of 30 kg P_2O_5 ha^{-1} exhibited a significant effect on P uptake (Table 4.14). This might be due to less availability of native phosphorus during the initial stage of crop growth wherein applied phosphorus upto 30 kg P_2O_5 ha^{-1} improved the dry matter accumulation. These results are in agreement with Nagabhushana Rao (1990) who reported that application of phosphorus significantly enhanced the uptake of P at 30 DAS only.

Interaction effect between sunflower hybrids and phosphorus levels was not significant with respect to P uptake at different stages of crop growth (Table 4.14 and 4.15).

CONCLUSIONS

From the above discussion, the following conclusions can be drawn. All the sunflower hybrids studied can be grown successfully in Bapatla area even though it is not a traditionally sunflower growing tract with yield realization ranging from 1150 kg ha^{-1} in KBSH-1 to 2174 kg ha^{-1} in MSFH-8. MSFH-8 was found to be superior with better growth (Plant height and dry matter production), higher yield attributes except head diameter and 1000-seed weight. The highest seed and oil yield of 2174 kg ha^{-1} and 899.4 kg ha^{-1}, respectively was recorded by this hybrid.

Phosphorus had no significant effect on growth parameters, yield attributes, yield (seed, stalk and oil), oil content and P uptake except at early stages of crop growth (30 DAS) in LAI, dry matter accumulation and P uptake.

Summary

CHAPTER - VI

SUMMARY

A field experiment entitled "Response of sunflower cultivars to levels of phosphorus in rabi season" was conducted at Agricultural College Farm, Bapatla on sandy soil with transported clay loam soil on the top 30cm depth during rabi season, 1996-'97 to find a suitable sunflower hybrid for South Coastal Andhra Pradesh and phosphorus needs of the crop. The experiment was laid out in split-plot design with three replications. The treatments consisted of four sunflower hybrids (APSH-11, KBSH-1, MSFH-8 and MEGA-363) assigned to main plots and four phosphorus levels (0, 30, 60 and 90 kg P_2O_5 ha^{-1}) assigned to sub-plots. The experimental findings are briefly summarised here under.

At harvest, MSFH-8 recorded higher plant height, dry matter but had lower LAI values compared to other hybrids. At 30 and 60 DAS maximum stem girth was observed with MEGA-363 and was significantly superior to the rest of the hybrids. MSFH-8 came to 50 per cent flowering later than the other three hybrids. Yield attributes like number of filled seeds per head, per cent filled seeds and filled seed weight per head were significantly higher in MSFH-8 than the other hybrids. Whereas, head diameter and head weight were significantly more in MEGA-363 but it was comparable with APSH-11 in terms of head diameter and MSFH-8 interms of head weight. Highest test weight (1000-seed weight) was recorded in KBSH-1 and was significantly superior to all other hybrids. However yield attributes (except test weight) were lowest recorded in KBSH-1.

Seed yield was significantly higher in MSFH-8 over MEGA-363, APSH-11 and KBSH-1. Higher stalk yields were obtained in MEGA-363 and MSFH-8 and both of them were significantly superior to KBSH-1 and APSH-11. The harvest index values were significantly higher both in MSFH-8 and APSH-11 than KBSH-1 and MEGA-363 with a non-significant differences between the former two and latter two hybrids. Higher oil content and oil yield were recorded in MSFH-8 followed by MEGA-363, APSH-11 and KBSH-1. MSFH-8 recorded higher uptake of P by both seed and stalk, however it was at a par with MEGA-363 in respect of uptake of P by stalk.

Phosphorus levels during the early stages of crop growth (30 DAS) significantly influenced the dry matter production, LAI and P uptake. But, at later stages (60 DAS and harvest) phosphorus levels did not influence the same. The remaining growth parameters (except days to

50% flowering) like plant height and stem girth did not respond to phosphorus application. Yield attributes, seed yield, stalk yield, harvest index, oil content and oil yield were also not significantly influenced by phosphorus application.

Interaction effects of sunflower hybrids and phosphorus levels were observed both at 60 DAS and harvest in respect of plant height and stem girth of sunflower. Both at 60 DAS and harvest, maximum plant height was recorded with MSFH-8 when no phosphorus was applied and maximum stem girth was obtained with the combination of MEGA-363 and 90 kg P_2O_5 ha^{-1}.

From the above results the following inferences can be drawn; MSFH-8 was found to be better than the other hybrids tried, in terms of seed yield and other yield attributing characters except head diameter and test weight. Application of phosphrous may not be beneficial to sunflower when the soil available phosphorus is medium under irrigated conditions during rabi season.

Literature Cited

LITERATURE CITED

*Adiseshaiah K 1976 Effect of different levels of nitrogen and phosphorus on yield and yield components of two sunflower varieties under rainfed conditions. Thesis abstracts 2: 171.

Adiseshaiah K, Yogeswara Rao Y and Sankara Reddy G H 1978 Response of two sunflower varieties to different levels of nitrogen and phosphorus under rainfed conditions. Oilseeds Journal 8: 11-13.

Bhosale R J, Patil B P and Wadkar S S 1979 Effect of graded levels of nitrogen and phosphorus on the yield of sunflower variety Peredavik under rabi irrigated conditions in Konkan region. Indian Journal of Agricultural Research 13: 164-166.

Bhowmik N N, Sarkar R K and Ravi N M 1994 Response of sunflower to phosphorus and potassium application. Indian Agriculturist 38: 141-143.

Chaniara N J, Patel J C, Malavia D D and Baldha N M 1989 Effect of irrigation, nitrogen and phosphorus on the productivity of sunflower. Indian Journal of Agronomy 34: 399-401.

Chaudhary C S and Paturde J T 1981 Effect of nitrogen and phosphorus on seed and oil yield of sunflower. Indian Journal of Agriculture Research 15: 141-144.

Daulay H S and Singh K C 1980 Fertilizer use in rainfed sunflower. Indian Journal of Agricultural Sciences 50: 825-828.

Dhaka R V S and Agrawal J P 1981 Effect of plant densities and levels of N and P on the yield of sunflower. Agriculture Science Digest 1: 91-93.

Directorate of Economics and Statistics 1995 Agricultural Situation in India 52: 645.

Directorate of Economics and Statistics 1996 Andhra Pradesh Economic and Statistical Bulletin pp.9.

Directorate of Oilseeds Research (DOR) 1987 Effect of NPK on seed yield, 100-seed weight and oil content of sunflower variety SUF-3 (Coimbatore). Annual Progress Report on Sunflower 32: 64-65.

Directorate of Oilseeds Research (DOR) 1988 Influence of NPK levels on seed yield and ancillary characters. Annual Progress Report on Sunflower 34:102.

Directorate of Oilseeds Research (DOR) 1989 Influence of NPK levels on seed yield and ancillary characters of sunflower at Coimbatore. Annual Progress Report on Sunflower 35: 81.

*El-Sayed M M, Mohamed L K and Ebaid M M 1985 Effect of plant spacing, nitrogen and phosphorus rates on yield, its components and oil of sunflower variety Giza 1 (Helianthus annuus L.). Field Crop abstracts 38: 3181.

*Gaur S L, Bangar A R and Kadam S K 1989 Effect of graded doses of nitrogen, phosphorus and potassium on the yield and oil content of sunflower. Field Crop abstracts 42: 4643.

Gaur B L, Tomar D S and Trehan K B 1973 A note on the effect of different levels of nitrogen and phosphorus on the yield of sunflower. Indian Journal of Agronomy 18: 109-110.

*Gawande S K 1990 Effect of graded levels of phosphorus on root CEC, uptake of nutrients and yield of sunflower varieties. Thesis abstracts 16: 7-8.

*Girase P D, Deokar A B and Patil G D 1977 Studies on the effects of various levels of nitrogen and phosphorus on growth, yield and oil content of sunflower. Field crop abstracts 30: 1163.

Goswami N N and Kamat M B 1984 Fertilizer use Research on phosphorus and its utilization by crop and cropping systems. Fertilizer News 29: 22-24.

Graham J H, Leownard R T and Meng J A 1981 Membrane-mediated decrease in root exudation responsible P inhibition of vasicular-Arbuscular Mycorrhiza formation. Plant Physiology 68: 548-552.

Gupta H K and Sharma T R 1978 A note on the response of sunflower to nitrogen and phosphorus under rainfed conditions. Oilseeds Journal 8: 58.

Hedly M J, Nye P H and White R E 1983 Plant induced changes in the rhizosphere of rape (Brassica napus var. Emerald) seedlings IV. The effect of rhizosphere phosphorus status on the pH, phosphatase activity and depletion of soil phosphorus fractions in the rhizosphere and on the cation-anion balance in the plants. New Phytologist 95: 69-82.

*Hiramath B R, Patil V S, Biradar D P and Hunshal C S 1992 Response of sunflower genotypes to levels of nitrogen and phosphorus fertilization. Field crop abstracts 45: 8772.

Hoffland E, Findenegg G R and Nelemans J A 1989 Solubilization of rock phosphate by rape I.Evaluation of the role of the nutrient uptake pattern. Plant and Soil 113: 155-160.

Jackson M L 1973 Soil chemical analysis. Prentice Hall of India Private Limited, New Delhi pp.198.

Jagtap S M and Sabale R N 1994 Effects of nitrogen and phosphorus on the yield attributes and yield of sunflower varieties. Journal of Maharastra Agricultural University 19: 480-481.

Kalra G S and Tripathi 1980 Nutrient uptake and quality of sunflower as influenced by NPK fertilization. Indian Journal of Agronomy 25: 710-716.

*Kandalkar A B 1991 Effect of plant density, levels of phosphate and irrigation on growth, yield and consumptive use of sunflower (Helianthus annuus L). Thesis abstracts 17: 24.

Kandalkar A B, Bharad G M, Wankhade S T and Khan I A 1991 Effect of levels of plant density, phosphate and irrigation on growth and yield of sunflower. Annals of Plant Physiology 5: 81-84.

*Khokhani M G 1991 Effect of different levels of nitrogen and phosphorus on growth and yield of rabi sunflower under S. Gujarat conditions. Thesis abstracts 17: 103.

Khokhani M G, Ahlawat R P S and Tridevi S J 1993 Effect of nitrogen and phosphorus fertilizers on yield and nutrient uptake in sunflower. Indian Journal of Agronomy 38: 330-332.

*Kumar D S R and Basava Raju G V 1985 Role of plant nutrients on the quality of hybrid seeds of sunflower. Field crop abstracts 38: 6714.

*Leon F J C and Moreno R O H 1985 Response of sunflower (Helianthus annuus L.) to nitrogen, phosphorus and plant density in the yaqui valley, Son. Field crop abstracts 38: 5888.

*Lewis D C, Potter T D and Weckert S E 1992 The effect of nitrogen, phosphorus and potassium fertilizer application on the seed yield of sunflower

(Helianthus annuus L.) grown on sandy soils and the prediction of phosphrous and potassium responses by soil tests. Field crop abstracts 45: 1132.

*Loubser H L, Grim beek C L and Bron khorst B 1990 Effect of fertilizers on sunflower I. Seed yield. Field crop abstracts 43: 4397.

*Maatouk M A and El-latif L I A 1986 Quality of sunflower seeds and N P contents and their uptake as influenced by N P fertilization in sandy soil. Field crop abstracts 39: 8864.

*Maheswarappa K P, Shambulingappa K G, Basavaraju G V and Kumar D S R 1986 Role of N and P fertilization on test weight, protein, oil and germination of BSH-1 sunflower. Field crop abstracts 39: 6335.

Megur N C, Prabhakar A S, Hosmani M M and Kalaghatagi S B 1993 Effect of nitrogen and phosphorus on growth and grain yield of sunflower. Journal of Oilseeds Research 10: 127-128.

Mishra A, Das P and Paikaray R K 1994 Performance of sunflower in relation to nitrogen and phosphorus in acid soils of Orissa. Journal of Oilseeds Research 11: 288-290.

Mishra A, Das P and Paikaray R K 1995 Yield and nutrient uptake by winter sunflower (Helianthus annuus L) as influenced by nitrogen and phosphorus. Indian Journal of Agronomy 40: 137-138.

Misra N M and Avijit sen 1986 Phosphorus and potash fertilization studies on sunflower. Madras Agriculture Journal 73: 163-165.

Moorby H, White R E and Nye P H 1988 The influence of phosphate nutrition on H ion efflux from the roots of young rape plants. Plant and Soil 105: 247-256.

Nagabhushana Rao A 1990 Effect of levels of nitrogen and phosphorus on yield and quality of sunflower (*Helianthus annuus* L.) M.Sc.(Ag.) thesis, Andhra Pradesh Agricultural University, Hyderabad.

Naphade P S and Naphade K T 1991 Root CEC and P fertilization in sunflower. Annals of Plant Physiology 5: 247-252.

Narayanan K and Iruthayaraj M R 1984 Effect of irrigation and fertilizer levels on sunflower Morden variety. Oils and Oilseeds Journal 37: 55-56.

Narsi Reddy C H and Madan Mohan Reddy T 1993 Response of phosphorus and sulphur fertilization in sunflower. Journal of Research APAU 21: 235-236.

Olsen S R, Cole C V, Watanabe F S and Dean L A 1954 Estimation of available phosphorus in soils by extraction with sodium bicorbonate. USDA circular pp. 939.

Piper C S 1966 Soil and plant analysis. University of Adelaide, Australia. pp. 277-306.

Prabhuraj D K, Badiger M K and Manure G R 1993 Growth and yield of sunflower (*Helianthus annuus*) as influenced by levels of Phosphorus,Sulphur and Zinc Indian Journal of Agronomy 38: 427-430.

Rao P M, Raju A S and Rao T M V 1984 Relative efficiency of utilization of soil and fertilizer phosphorus by crops in red (chalka) soils. Journal of Nuclear Agriculture and Biology 13: 18-21.

Rao Y Y, Reddy M V and Shankara Reddy G H 1973 Response of sunflower to nipping of terminal bud and fertility levels. Oilseeds Journal 3: 62-65.

Raut R S and Ghonsikar C P 1978 Effect of phosphorus and sulphur levels on yield and oil content of sunflower (Helianthus annuus L.). Oilseeds Journal 8: 36-38.

Richards L A 1954 Diagnosis and improvement of saline and alkali soils. USDA Agriculture Hand Book No.60 pp.7-19.

Riley D and Barber S A 1971 Effect of ammonium and nitrate fertilization on phosphorus uptake as related to root induced pH changes at the root-soil interface. Soil Science Society of America Proceedings 35: 301-306.

*Rollier M, Trocme S and Boniface R 1976 Observations on the application of phosphorus - potassium fertilizer to sunflowr. Field crop abstracts 29: 6706.

Sarkar R K, Chakraborty A and Bala B 1995 Response of sunflower (Heliathus annuus) to crop geometry and nitrogen and phosphorus application on rice-fallow gangetic alluvial soil. Indian Journal of Agronomy 40: 657-659.

Sathiyavelu A, Panneerselvam R, Arunachalam L and Purushothaman S 1994 Effect of nitrogen, phosphorus and potassium on yield of sunflower (Helianthus annuus) under rainfed condition. Indian Journal of Agronomy 39: 499-500.

*Sen D P 1979 Newer sources of oil and fats. Abstracts of Technical papers. International congress on Oilseeds and Oils. February 9-13, 1979 New Delhi pp.30.

Shanthamallaiah N R, Shivaraj B, Patil N M and Veeranna V S 1977 Effect of plant population and fertilizer levels on growth, yield and yield components in sunflower. Mysore Journal of Agricultural Sciences 11: 477-480.

*Shelke V B, Shinde V S, Dahiphale V V and Chavan D A 1990 Effect of levels of nitrogen, phosphorus and potassium on growth and yield of *rabi* sunflower. Field Crop abstracts 43: 6800.

Sidhu M S, Sahota T S, Sharma B D and Sawhney J S 1991 Nitrogen and phosphorus requirement of sunflower as affected by different cropping systems and agronomic practices. Fertilizer News 36: 35-38.

Singh U B and Singh R M 1980 Effect of graded levels of moisture regime, N and P fertilization on seed yield, oil content and NPK uptake by safflower. Indian Journal of Agronomy 25: 9-17.

Singh P P and Kaushal P K 1975 Effect of nitrogen and phosphorus rates and spacings on the seed yield and yield attributing characters of sunflower. Mysore Journal of Agricultural Sciences 9: 660-663.

Singh S P, Verma U K and Mandal B 1977 Effect of fertility status and plant population on the performance of sunflower varieties at Sabour. Indian Journal of Agronomy 22: 130.

Singhi S M and Pacheria 1981 Effect of varying row spacing, nitrogen and phosphorus levels on sunflower. Indian Journal of Agronomy 26: 20-23.

Somasundaram S and Iruthayarai M R 1981 Effect of irrigation regimes and phosphorus levels on yield and yield attributes in sunflower (*Helianthus annuus* L.). Indian Journal of Agricultural Sciences 15: 215-222.

Subbiah B V and Asija G L 1956 Alkaline permanganate method. Current Science 25: 258-260.

Sumio Itoh and Barber S A 1983 Phosphorus uptake by six plant species as related to root hairs. Agronomy Journal 75: 457-461.

Sundara Rajan M, Nagaraju S, Venkata Ramu M N and Jagannadh M K 1972 Design and analysis of field experiments. University of Agricultural Sciences, Hebbal, Bangalore pp. 293-302.

Tandon H L S 1987 Phosphorus Research and Agricultural production in India. Fertilizer Development and Consultation Organisation, New Delhi pp. 82-160.

Tarakeswara Rao Y, Chandrasekhara Reddy and Yellamanda Reddy T 1989 Effect of phosphorus levels at different plant densities on yield and yield attributes of sunflower. Andhra Agricultural Journal 36: 367-370.

Thomas Varghese P, Sadanandan N and Vikraman Nair R 1976 A study on leaf area index and net assimilation rate of sunflower (Helianthus annuus L.) variety peredavik as affected by graded doses of nitrogen and phosphorus. Agriculture Research Journal of Kerala 14: 53-57.

Tisdale S L, Nelson W L, Beaton J D and Havlin J L 1993 Soil fertility and fertilizers. Macmillan Publishing Co., New York pp.196-198.

Tiwary P N, Gambhit P N and Rajan T S 1974 Rapid and non-destructive of seed oil by pulsed nuclear magnetic resonance technique. Journal of American Oil Chemical Society 57: 305-308.

Tripathi P N and Kalra G S 1981 Effect of NPK on maturity and yield of sunflower. Indian Journal of Agronomy 26: 66-70.

Varma S K, Malik B S and Agrawal M C 1976 Effect of nitrogen application under varying soil moisture regimes on the uptake of nutrients by barley. Indian Journal of Agronomy 21: 318-320.

Venkata Rao B V and Govindarajan S V 1956 Mysore Agricultural Journal 31: 232 (Cited in phosphorus in soils, crops and fertilizers. Bulletin No.12, Published in 1979 by Dr.A.B.Ghosh, Indian Society of Soil Science pp.111).

*Vig A C and Singh N T 1983 Yield and P uptake by wheat as affected by P fertilization and soil moisture regimes. Fertilizer Research 4: 21-30.

Vikram Singh, Chunmun Singh and Singh T P 1973 Note on the yield response of sunflower to the application of nitrogen and phosphorus under tarai conditions. Indian Journal of Agricultural Sciences 43: 890-891.

Vivek Chakor I S and Sharma S K 1993 Effect of irrigation and phosphorus levels on the yield of sunflower under foot hill conditions of Himachal Pradesh. Agricultural Science Digest 13: 147-148.

Voinescu A, Terbea M, Hera C and Mahaila V 1986 Some physiological aspects connected with the application of N and P mineral fertilizer to the sunflower crop. Field Crop abstracts 39: 8853.

* Original not seen

NOTE: Literature cited has been coated as per the ANGRAU thesis guidelines.

Appendices

APPENDIX - A

CALENDER OF OPERATIONS

Date	Operation
08-12-1996	Ploughing with tractor followed by harrowing
10-12-1996	Field cleaning and lay out
13-12-1996	Sowing and basal application of fertilizers
23-12-1996	Thinning and Gap filling
07-01-1997	Hand weeding
12-01-1997	Top dressing of N
23-01-1997	NPV spraying
25-01-1997	Hand picking of tobacco caterpillars
01-02-1997	Top dressing of N
	HARVESTING
12-03-1997	APSH-11 and KBSH-1
16-03-1997	MSFH-8 and MEGA-363
12-03-1997 To 24-03-1997	Sundrying of heads
25-03-1997	Threshing