EFFECT OF POTASSIUM AND SULPHUR ON GROWTH, YIELD AND QUALITY OF SUMMER PEARL MILLET
(Pennisetum glaucum (L.) R. Br. Emend Stuntz)

BY
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DEPARTMENT OF AGRONOMY
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SUBMITTED TO THE
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IN PARTIAL FULFILMENT OF REQUIREMENTS
FOR THE AWARD OF THE DEGREE
OF

MASTER OF SCIENCE
(Agriculture)

IN
AGRONOMY

BY
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COLLEGE OF AGRICULTURE
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JUNAGADH - 362001

JULY - 2012
Registration No:- J4-00597-2010
DEDICATED TO
MY
PARENTS
FOR THEIR
DREAMS, HOPES & ENDLESS
PRAYERS
& MY RESPECTED GUIDE

NIRAV....
ABSTRACT
EFFECT OF POTASSIUM AND SULPHUR ON GROWTH, YIELD AND QUALITY OF SUMMER PEARL MILLET
[Pennisetum glaucum (L.) R. Br. Emend Stuntz]

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<th>Major Guide</th>
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<td>Dr. H. R. Khafi</td>
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DEPARTMENT OF AGRONOMY
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ABSTRACT

A field experiment entitled “Effect of potassium and sulphur on growth, yield and quality of summer pearl millet [Pennisetum glaucum (L.)]” was conducted on medium black soil at the Instructional Farm, Junagadh Agricultural University, Junagadh (Gujarat) during the summer season of 2011. The experiment, comprised sixteen (16) treatment combinations was laid out in factorial randomized block design and replicated three times. The treatment consisted combinations of four levels of potassium viz., no potassium (K₁), 60 kg K₂O ha⁻¹ (K₂), 90 kg K₂O ha⁻¹ (K₃), 120 kg K₂O ha⁻¹ (K₄) and four levels of sulphur viz., no sulphur (S₁), 20 kg S ha⁻¹ (S₂), 30 kg S ha⁻¹ (S₃) and 40 kg S ha⁻¹ (S₄). The recommended dose of N and P were applied uniformly to all the treatments at basal. Potassium and sulphur were applied as basal in form of muriate of potash and gypsum, respectively.
Experimental results indicated significantly higher plant height at 30 DAS (28.4 cm), 45 DAS (133.3 cm) and at harvest (156.9 cm), number of total tillers per plant (4.09), number of effective tillers per plant (2.74), earhead length (25.03 cm), earhead girth (3.28 cm) and test weight (9.45 g) with an application of 120 kg K₂O ha⁻¹. Higher grain and fodder yields of 3629 and 6917 kg ha⁻¹, respectively were also recorded by potassium application @ 120 kg K₂O ha⁻¹.

Significantly higher oil (3.45 %) were recorded with an application of 120 kg K₂O ha⁻¹ as compared to other treatments. Potassium fertilization had no significant influence on protein contents of pearl millet grains. In comparison to control, an application of potassium @ 120 kg K₂O ha⁻¹ showed appreciably higher nitrogen, phosphorus, potassium and sulphur uptake by grain and fodder as compared to without potassium application. Potassium fertilization had no significant influence on content of nitrogen, phosphorus and sulphur however an application of 120 kg K₂O ha⁻¹ resulted in significantly more potassium content by grain and fodder. Potassium fertilization had no significant influence on residual availability of sulphur however an application of 120 kg K₂O ha⁻¹ resulted in significantly more available potassium in soil. Economic evaluation of potassium levels revealed that the highest net returns of ₹ 22888 ha⁻¹ and B:C ratio of 2.36 were obtained with an application of 120 kg K₂O ha⁻¹.

Application of sulphur @ 40 kg S ha⁻¹ significantly increased plant height at 30 DAS (28.3 cm), 45 DAS (133.3 cm) and at harvest (154.9 cm), number of total tillers per plant (4.08), number of effective tillers per plant (2.73), earhead length
(24.94 cm), earhead girth (3.27 cm) and test weight (9.44 g). Sulphur fertilization to pearl millet @ 40 kg S ha\(^{-1}\) significantly augmented higher grain and fodder yields of 3619 and 6875 kg ha\(^{-1}\), respectively.

Fertilizing pearl millet with 40 kg S ha\(^{-1}\) significantly increased oil (3.54 %) contents over control. Sulphur fertilization had no significant influence on protein contents of pearl millet grains. An application of sulphur @ 40 kg S ha\(^{-1}\) showed significant increment in respect by nitrogen, phosphorus, potassium and sulphur uptake of grain and fodder as compared to without sulphur application. Sulphur fertilization had no significant influence on content of nitrogen, phosphorus and potassium of grain and fodder. However an application of 40 kg S ha\(^{-1}\) resulted in significantly more sulphur content by grain and fodder. Sulphur fertilization had no significant influence on residual availability of potash; however an application of 40 kg S ha\(^{-1}\) resulted in significantly more available sulphur in soil as compared to control. Economic evaluation of sulphur levels revealed that the highest net return of ₹ 24299 ha\(^{-1}\) and B:C ratio of 2.58 were obtained with an application of 40 kg S ha\(^{-1}\).

Based on the one year experimental results, it was concluded that better crop yield and higher net return can be obtained from summer pearl millet (cv. GHB-538) by fertilizing the crop with 120 kg K\(_2\)O ha\(^{-1}\) and 40 kg S ha\(^{-1}\) along with recommended fertilizer dose (120 kg N ha\(^{-1}\) + 60 kg P\(_2\)O\(_5\) ha\(^{-1}\)) in the medium black calcareous soil of South Saurashtra Agro climatic zone of Gujarat.
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Junagadh Agriculture University,  
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CERTIFICATE

This is to certify that the thesis entitled "EFFECT OF POTASSIUM AND SULPHUR ON GROWTH, YIELD AND QUALITY OF SUMMER PEARL MILLET [Pennisetum glaucum (L.) R. Br. Emend Stuntz]" submitted by Mr. CHAUDHARI NIRAVKUMAR NANUBHAI in the partial fulfilment of the requirements for the award of the degree of MASTER OF SCIENCE in AGRONOMY to the JUNAGADH AGRICULTURAL UNIVERSITY is a record of bonafide research work carried out by him under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma or other similar title.

Place: Junagadh  
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Date: 12/09/2012

This is to certify that CHAUDHARI NIRAVKUMAR NANUBHAI has successfully completed the comprehensive/preliminary examination held on 11/06/2012 as required under the regulation for Post-Graduate Studies.

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Major Guide and Research Scientist (Agron.), Main Millet Research Station, Junagadh Agricultural University, Jamnagar.
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Place : Junagadh
Date : 5th July, 2012

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ABBREVIATIONS USED IN PRESENT THESIS

% : Per cent
& : and
@ : At the rate of
°C : Degree Celsius
/ : Per
Anon. : Anonymus
BCR : Benefit Cost Ratio
C. V. : Coefficient of Variance
C.D : Critical Difference
cm : Centimetre
DAP : Diammonium phosphahte
DAS : Days After Sowing
et al. : co-worker
etc : etcetera
Fig. : Figure
g : gram
GHB 538 : Gujarat Hybrid Bajara 538
ha : hectare
hr : hour
kg : kilogram
K : Potassium
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<td>m</td>
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<td>MOP</td>
<td>Muriate of Potash</td>
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<tr>
<td>Max.</td>
<td>Maximum</td>
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<tr>
<td>Min.</td>
<td>Minimum</td>
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<tr>
<td>mm</td>
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<td>N</td>
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<td>NS</td>
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<tr>
<td>P</td>
<td>Phosphorus</td>
</tr>
<tr>
<td>q</td>
<td>quintal</td>
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<tr>
<td>RH</td>
<td>Relative Humidity</td>
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<tr>
<td>₹</td>
<td>Rupees</td>
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<tr>
<td>S.Em.</td>
<td>Standard Error of Mean</td>
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<tr>
<td>Sig.</td>
<td>Significant</td>
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<tr>
<td>S</td>
<td>Sulphur</td>
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INTRODUCTION
Pearl millet [*Pennisetum glaucum* (L.) Br. R. Emend Stuntz] is one of the major coarse grain cereal crop and is considered to be a poor people's food. It is widely grown in Africa and Asia since pre-historic times. In Asia, important pearl millet growing countries are India, China, Nigeria, Pakistan, Sudan, Egypt, Arabia and Russia. In India, it is one of the important millet crops. It provides staple food for poor people.

Pearl millet is the staple cereal in arid and semi-arid regions of country. It is the only cereal crop that is capable of producing a reliable yield under the marginal environments and simultaneously responds to high management conditions. Its nutritious grain forms the important ration for ruminant livestock during the dry season. In addition, pearl millet grain is increasingly being used as feed for livestock and poultry.

Pearl millet is a crop grown mostly in tropical climate. It is grown under adverse climatic conditions in relatively arid region of the country. It is the most drought tolerant crop among cereals and millet. India is the largest producer of pearl millet with an annual production of 3.984 lakh tonnes from an area of 1.752 lakh ha and productivity of 2274 kg ha\(^{-1}\) during summer and annual production of 62.054 lakh tonnes from an area of 87.412 lakh ha with productivity of 710 kg ha\(^{-1}\) during *Kharif* (AICPMIP-2011). Gujarat has an area of 1.742 lakh hectares producing 3.964 lakh tonnes with productivity of 2276 kg ha\(^{-1}\) during summer and area of 4.988 lakh hectares producing 4.324 lakh tonnes with productivity of 867 kg ha\(^{-1}\) during *Kharif* (AICPMIP-2011).
Banaskatha, Junagadh, Jamnagar, Rajkot, Mehsana, Kheda, Amerali and Kutch are the major pearl millet growing districts of Gujarat.

Pearl millet is an important coarse grain cereal generally grown as rainfed crop on marginal lands under low input management conditions. It is adapted to drought and poor soil fertility but responds well to good management and higher fertility levels. It is generally cultivated in area with rainfall ranging from 150 to 600 mm. It is a dual purpose crop, its grain is used for human consumption and its fodder as cattle feed. Pearl millet is a small seeded caryopsis.

Fertilizers, even though comparatively a costly input of production are essential for securing higher yields. The prudent use of fertilizers with appropriate method and time of application are the prime importance in securing higher and economic yields.

The contribution of fertilizer in increasing agricultural production has been very well demonstrated in India and elsewhere. From the study made in U.S.A., it was found that fertilizer was the largest single factor responsible for increasing total crop production and recounted for 50 per cent increase in yield (Randhawa and Dev, 1972).

At present, the farmers are using excess chemical fertilizer which lead to nutrient deficiency of other than applied and declined in organic carbon. An excess use of chemical fertilizer spoils the structure and texture of the soil. Therefore use of chemical fertilizer alone may not keep pace with time in maintenance of soil health for sustaining the productivity.
Potassium is one of the major plant nutrients for the growth and development of plants. The major functions are enzyme involved in photosynthesis, metabolism of carbohydrate and physiological processes such as root growth, water uptake and utilization efficiency, synthesis of protein and amino acids, enzyme activation and yield determining process viz, drought, pest and disease tolerance. The loss of water through transpiration can be minimized by K application (Nelson, 1982). When it is not available in adequate quantities, it limits crop production whereas application in excess leads to wistful luxury consumption. The potassium also improves crop quality and yield characteristics in a number of crops.

Potassium is a major nutrient because of the large amount required by the plant in which it is absorbed by plants and its significant place for the production of high yield. The importance of potassium in Indian agriculture is increasing with the passage of time. The crop response to application of potassium is becoming more frequent and pronounced. Usage of fertilizer potassium is approaching 900 thousand tones K₂O and intensive crop rotation can remove 200-500 kg K₂O ha⁻¹ in India. Yet on unit area basis, current usage of K₂O is 5 kg ha⁻¹ as compared to 32 kg for N and 12 kg for P₂O₅ ha⁻¹.

Similarly, sulphur is now recognized as the 4th major plant nutrient along with nitrogen, phosphorus and potassium therefore is now very much a part of balanced fertilization because in sulphur deficient areas, applying NPK fertilizer only cannot ensure high yields unless sulphur is also applied. Sulphur performs important functions in the plant. It is the best known for its role in the synthesis of proteins, oils and vitamins.
Potassium is one of the major plant nutrients for the growth and development of plants. The major functions are enzyme involved in photosynthesis, metabolism of carbohydrate and physiological processes such as root growth, water uptake and utilization efficiency, synthesis of protein and amino acids, enzyme activation and yield determining process viz, drought, pest and disease tolerance. The loss of water through transpiration can be minimized by K application (Nelson, 1982). When it is not available in adequate quantities, it limits crop production whereas application in excess leads to wistful luxury consumption. The potassium also improves crop quality and yield characteristics in a number of crops.

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Similarly, sulphur is now recognized as the 4th major plant nutrient along with nitrogen, phosphorus and potassium therefore is now very much a part of balanced fertilization because in sulphur deficient areas, applying NPK fertilizer only cannot ensure high yields unless sulphur is also applied. Sulphur performs important functions in the plant. It is the best known for its role in the synthesis of proteins, oils and vitamins.
It is a constituent of three amino acids and thus vital for protein production. Sulphur is associated with the production of crops for superior nutritional and market quality produce.

Low yield subsistence agriculture based on exploiting the natural reserve of soil sulphur and sulphur supplied to agro-ecosystems from atmosphere through rain, dust and by gaseous absorption as well as irrigation water, manures and fertilizers have led to inadequate attention for sulphur fertilization.

However, in last few years, sulphur application to soil becomes necessary because of (I) the replacement of ammonium sulphate, single super phosphate and sulphate of potassium with urea, diammonium phosphate and muriate of potash, respectively, (II) the focus on modern agriculture on high yielding varieties, (III) greater use of high analysis fertilizers, (VI) intensive cropping and (V) decrease in the use of farm yard manure. Thus, now a days, the deficiency of sulphur is becoming more evident.

Potassium and sulphur play a vital role in the nutrition of plants. In fact, these nutrients are lacking mostly in the soils. Fertility analysis of Indian soils has indicated that the soils are deficient in sulphur and medium to low in the potash. Therefore, application of chemical fertilizers becomes essential to raise the crop yield. No research work has been done on the effect of potassium and sulphur on yield and quality of pearl millet crop in this region. Taking note of the fact highlighted above, an experiment entitled “Effect of potassium and sulphur on growth, yield and quality of summer pearl millet [Pennisetum glaucum (L.)]” during 2011 was undertaken with the following objectives:
1. To find out the effect of varying levels of potassium and sulphur on growth, yield attributes, yield and quality of pearl millet.

2. To study the effect of potassium and sulphur on nutrient content and uptake by the crop.

3. To Study the interaction effect of potassium and sulphur on yield and yield attributes of pearl millet.

4. To arrive at an economically viable conclusion for higher pearl millet yield.
REVIEW
OF
LITERATURE
An attempt has been made in this chapter to review the available literature concerning to the present investigation entitled “Effect of potassium and sulphur on growth, yield and quality of summer pearl millet.” The work done related to these aspects on pearl millet crop is limited and hence similar works on other crops have also been included wherever felt necessary. A brief summary of research work related to the aspects have been highlighted and reviewed under the following broad topics:

2.1 EFFECT OF POTASSIUM

2.1.1 Plant growth parameters
2.1.2 Yield and yield attributes
2.1.3 Quality parameters
2.1.4 Content and uptake of nutrients

2.2 EFFECT OF SULPHUR

2.2.1 Plant growth parameters
2.2.2 Yield and yield attributes
2.2.3 Quality parameters
2.2.4 Content and uptake of nutrients

2.3 INTERACTION EFFECT BETWEEN POTASSIUM AND SULPHUR

2.1 EFFECT OF POTASSIUM

Potassium is extremely mobile cation within the plant and helps in regulating the opening and closing of stomata and the uptake of water by root cells. Potassium is essential for photosynthesis, protein synthesis, starch formation and translocation of sugars. Although its availability is medium to high in soil, the introduction of high yielding varieties and use of
high dose of nitrogenous and phosphatic fertilizers under intensive cropping is likely to depleted soil potassium. Hence, response to potassium application is likely. Available literature with regards to K response to pearl millet is summarized under.

2.1.1 Plant growth parameters

Jain and Poonia (2003) reported that an application of inorganic nutrients up to 24.9 kg K ha\(^{-1}\) significantly improved the growth parameters such as tillers per meter row length and plant height of pearl millet.

Singh et al. (2003) conducted a study at Rahuri, Varanasi, Uttar Pradesh, India. They observed that an application of potassium @ 70 kg K\(_2\)O ha\(^{-1}\) significantly increased plant height, length of cob, girth of cob, number of rows per cob, number of grains per row and number of grains per cob of maize.

More et al. (2004) conducted a field experiment at Rahuri, Maharashtra, India. They stated that application of potassium 120 kg ha\(^{-1}\) significantly increased plant height, length of cob, girth of cob, number of rows per cob, number of grains per row and number of grains per cob of maize.

Sofi et al. (2005) reported the effect of different levels of potassium (0, 40 and 80 kg ha\(^{-1}\)) on the growth and yield of maize. They reported that an application of potassium up to 80 kg ha\(^{-1}\) significantly increased growth attributes like plant height, number of leaves per plant and plant dry weight of maize.

Rajput (2006) studied the effect of nutrient management for sustainable productivity in pearl millet in Morena, Madhya Pradesh, India. They revealed that an application of potassium @ 40 kg K\(_2\)O ha\(^{-1}\) resulted in the highest plant height and ear length of pearl millet.
Sheta et al. (2010) conducted an experiment in Anand Agricultural University, Anand (Gujarat), India. They stated that an application of 60 kg K₂O ha⁻¹ was found the best in increasing growth parameters such as tillers per meter row length, number of internodes per plant and plant height of pearl millet.

Kacha et al. (2011) studied at Junagadh Agricultural University, Junagadh (Gujarat), India. They reported that an application of 120 kg K₂O ha⁻¹ was found the best in increasing the plant height, total number tillers per plant, effective tillers per plant, earhead length and girth of pearl millet.

Yadav et al. (2011) revealed that an application of potassium @ 60 kg K₂O ha⁻¹ significantly increased the number of tillers, number of ear heads per plant and earhead length of pearl millet.

2.1.2 Yield attributes and yield

Choi et al. (1989) reported that effects of K on Pennisetum americanum fodder production and quality were assessed. In a comparison of 7 K formulations, av. fresh fodder yield ranged from 100 t with 15 kg K₂O to 134 t with 150 kg K₂O ha⁻¹. Av. fresh fodder yields with K application were 106, 50 and 83 t in P. americanum cv. Suwon 1, Zea mays cv. Suwon 19 and Sorghum bicolor X S. sudanense cv. GW 9110, respectively.

The results of a series of trials to determine suitable husbandry practices for P. americanum as a forage crop in Korea were presented. Optimum sowing depth was 2 cm under field conditions with optimum soil moisture but it was 4-6 cm under drier soil conditions. Green fodder yield was the highest with 16 May sowing and increased with increased K rates. Green fodder
yield was the highest with 400 kg K₂O ha⁻¹ on recently reclaimed upland soil. Cutting to a height of 20 cm every 4 weeks gave the best forage yields (Park et al., 1989).

Singh et al. (1992) reported that pearl millet [Pennisetum glaucum] cv. 83-104 and maize cv. Vijai grown in pots in loamy sand were given all combinations of 0, 50, 100 or 200 ppm K and 0, 5, 10, 20 or 50 ppm Zn. Dry matter yields increased with increasing K rates up to 100 ppm at low Zn rates, Millet yield in pots given 0-100 ppm K was the highest with 10 ppm Zn while at the highest K rate, the dry matter yield was the highest.

Patel and Karelia (1994) conducted the field experiments in the Mehsana district of Gujarat on bajra [Pennisetum glaucum] cv. B.J.-104. They reported that an application of potassium @ 60 kg K₂O ha⁻¹ significantly increased the grain yield of bajra.

Mehta et al. (1995) conducted the long-term field experiment in Haryana, India to study grain yield and depletion of native and applied K under pearl millet (Pennisetum americanum)-wheat and guar (Cyamopsis tetragonoloba)-wheat rotations. In the presence of P, an application of K significantly increased the grain yield in both rotations. Total annual removal of K was significantly higher in plot receiving maximum amounts of P and K (P₆₀K₉₀) than the control plots (P₀K₀).

Meisheri et al. (1995) studied the response and critical limit of potassium in soil and plant for pearl millet [Pennisetum glaucum] in 20 medium black calcareous soils varying in K status. They reported that an addition of potassium significantly increased grain and straw yields of pearl millet. Percentage grain yield response ranged from -34.2 to +48.7%
and -20.4 to +38.1% at the equivalent to 50 and 100 kg K$_2$O ha$^{-1}$, respectively.

Verma and Rajput (1999) conducted a field experiment at Bichpuri, Agra, Uttar Pradesh, India, on the effect of K on productivity and soil fertility in pearl millet. They observed the highest productivity and profitability of pearl millet with 40 kg K$_2$O ha$^{-1}$.

Grewal et al. (2000) carried out long-term fertilizer experiment in pearl millet at CCS, Haryana Agricultural University, Hisar, Haryana, India. They stated that an application of potassium (60 kg ha$^{-1}$) significantly increased the grain and straw yields of pearl millet.

Jain and Poonia (2003) reported that an application of inorganic nutrients up to 24.9 kg K ha$^{-1}$ significantly improved the growth and yield attributes as well as seed and straw yields of pearl millet.

An experiment was carried out from March to June of 2003 in order to evaluate the effect of potassium levels (0-0, 50-40, 100-80 and 150-120 kg ha$^{-1}$). A significantly higher grain yield was recorded in 120 kg K$_2$O ha$^{-1}$ (Araujo et al. 2004).

Bangar et al. (2004) conducted a field experiment in Maharashtra, India on the effect of K application on drought tolerance, nutrient uptake and yield of rainy season pearl millet hybrid Shradha (RHR-BH-8609) in dryland inceptisols and indicated that application of 30 kg K$_2$O ha$^{-1}$ registered significantly higher grain and stover yields of pearl millet.

Field experiment was conducted during 1989 and 1990 in Anantapur, Andhra Pradesh on pearl millet (*Pennisetum americanum* [*Pennisetum glaucum*]) genotypes and K uptake studies. Data were recorded for 50% flowering, maturity, plant
height, panicle length, basal tillers per plant, effective tillers per plant and fodder and grain yields per plant. Significant mean sum of squares for yield, yield components and K uptake indicated significant differences among the genotypes. Kumar and Sahib (2004) recorded the differential response of the genotypes in their ability to take up K followed by a similar trend during both years. MBH 110, WC-C 75, Mukta and HHB-60 were more efficient in K uptake per unit dry root weight.

More et al. (2004) conducted a field experiment in Rahuri, Maharashtra, India. They recorded that application of potassium @ 120 kg ha\(^{-1}\) significantly increased test weight and grain yield per plant of maize.

Gholve et al. (2005) experimented with 10 treatments involving an absolute control, 50 and 100% recommended dose of K. The recommended dose of K for pearl millet was 30 kg K\(_2\)O ha\(^{-1}\). The maximum productivity and net returns in addition to improvement in soil fertility status and chemical properties could be possible for pearl millet under dryland condition with the application of 50% recommended dose of K.

Rajput (2006) studied the effect of nutrient management for sustainable productivity in pearl millet in Morena, Madhya Pradesh, India. He reported that an application of potassium @ 40 kg K ha\(^{-1}\) resulted in the highest mean grain and stover yields and 1000-grain weight of pearl millet.

Yadav et al. (2006) conducted an experiment at Bawal, Haryana and found that fertilizing pearl millet with 90 kg K\(_2\)O ha\(^{-1}\) produced significantly higher grain yield as compared to control.

Grewal et al. (2007) conducted a field experiment on the effect of long-term application of potassium on yield and K
uptake by pearl millet in Hisar, Haryana, India during the kharif season. They revealed that an increase in grain and straw yields due to K application was significant up to 60 kg ha\(^{-1}\) to pearl millet.

Heidari and Jamshid (2010) studied the effects of different salinity levels and potassium supply on grain yield, yield components, carbohydrate content and nutrient uptake in pearl millet. They revealed that an application of potassium @ 200 kg K\(_2\)O ha\(^{-1}\) significantly increased grain yields and 1000-grain weight of pearl millet.

Sheta et al. (2010) conducted a field experiment in Anand Agricultural University, Anand (Gujarat), India. They stated that an application of 60 kg K\(_2\)O ha\(^{-1}\) significantly increased yield of green forage and dry matter yields of pearl millet.

Kacha et al. (2011) conducted a field experiment in Junagadh Agricultural University, Junagadh (Gujarat), India. They observed that an application of 120 kg K\(_2\)O ha\(^{-1}\) was the best to increase the test weight and grain and stover yields of pearl millet.

Tariq et al. (2011) revealed that grain yield was significantly increased as the supply of potassium rates increased from both K-fertilizer sources over control. However, maximum grain yield of maize was recorded in the treatment plot receiving 150 kg K\(_2\)O ha\(^{-1}\) from muriate and sulphate of potash in both silty clay loam and silt loam soils.

Yadav et al. (2011) revealed that an application of potassium @ 60 kg K\(_2\)O ha\(^{-1}\) significantly increased grain yield, straw yield and 1000-grain weight of pearl millet.
2.1.3 Quality parameters

Kalpana and Anbumani (2003) conducted a field experiment at Coimbatore, Tamil Nadu, India. They stated that an application of K at 50 kg ha\(^{-1}\) significantly improved crude protein content.

Yadav et al. (2006) conducted a study at Bawal (Haryana) on loamy sand soils. They revealed that an application of potassium at 60 kg K\(_2\)O ha\(^{-1}\) significantly increased protein content of grain of pearl millet.

Haji et al. (2009) conducted a field experiment on the response of maize hybrids to varying potassium (0, 100, 150, 200, and 250 kg ha\(^{-1}\)) application in Pakistan. They revealed that K application in all treatments significantly increased protein and oil contents over control in grains of maize.

Sheta et al. (2010) conducted a field experiment on loamy sand soil of Anand (Gujarat), India. They reported that an application of potassium @ 40 kg K\(_2\)O ha\(^{-1}\) significantly increased crude protein content and crude protein yield of pearl millet.

Brar et al. (2011) revealed that pearl millet grain protein content increased with an increase in K level from 0 to 60 kg K\(_2\)O ha\(^{-1}\).

2.1.4 Content and uptake of nutrients

Meisheri et al. (1995) studied the response on critical limit of potassium in soil and plant for pearl millet [\textit{Pennisetum glaucum}] in 20 medium black calcareous soils varying in K status. Addition of potassium (0, 50, 100 kg K\(_2\)O ha\(^{-1}\)) significantly increased concentration of K and uptake by pearl millet.
Mittal et al. (1996) carried out field trials during 1975-92 in pearl millet-wheat rotations to investigate the effects of K$_2$O 60 kg ha$^{-1}$. Laboratory analysis of samples after 12 years revealed that non-exchangeable K contributed 70-90% of total K removal which was confirmed by a significant relationship between non-exchangeable K and K fixation capacity. Potassium supply parameter values were also significantly and positively correlated to K removal indicating the utility of this parameter in assessing K availability in soils.

Bangar et al. (2004) conducted the field experiments in Maharashtra, India, to evaluate the effect of K application on nutrient uptake of rainy season pearl millet hybrid Shradha (RHR-BH-8609) in dryland and inceptisols indicated that an application of 30 kg K ha$^{-1}$ registered significantly higher grain, stover and K uptake by pearl millet.

Rajput (2006) studied the effect of nutrient management for sustainable productivity in pearl millet in Morena, Madhya Pradesh, India. An application of potassium @ 40 kg K ha$^{-1}$ resulted in the greatest total K uptake by pearl millet.

Grewal et al. (2007) conducted a field experiment on the effect of long-term application of potassium on yield and K uptake of pearl millet in Hisar, Haryana, India during the kharif season. The application 60 kg K ha$^{-1}$ significantly increased K uptake by grain and straw of pearl millet.

Haji et al. (2009) conducted a field experiment on the response of maize hybrids to varying potassium (0, 100, 150, 200, and 250 kg ha$^{-1}$) application in Pakistan. They revealed that the K application in all treatments significantly increased N, P, K concentration over control in stalk of maize.
Yadav et al. (2011) revealed that an application of potassium @ 60 kg K₂O ha⁻¹ significantly increased K uptake in grain and straw of pearl millet.

2.2 EFFECT OF SULPHUR

2.2.1 Plant growth parameters

Sarkar et al. (1991) observed the effects of 0, 20, 40 or 60 kg S ha⁻¹ as potassium sulphate, single superphosphate or zinc sulphate applied to pearl millet on a sandy loam soil. They reported that an application of potassium sulphate significantly increased the plant height of pearl millet.

Dadhich and Gupta (2003) carried out a field experiment in the semiarid eastern plain zone of Rajasthan, India. They stated that an application of 40 kg S ha⁻¹ significantly increased plant height of pearl millet.

Sharma and Gupta (2003) observed that an application of sulphur @ 60 kg S ha⁻¹ increased number of earheads per plant and seed number per earhead of pearl millet.

Dadhich and Gupta (2004) reported that plant height, leaves per plant, leaf area, stem girth and tillers per plant of pearl millet significantly increased with an application of sulphur up to 40 kg ha⁻¹.

Dadhich and Gupta (2005) conducted the field experiment in Jobner, Rajasthan, India, on loamy sand soil during the consecutive summer seasons. They reported that an application of sulphur @ 40 kg S ha⁻¹ significantly increased plant height and tillers per plant of pearl millet.

Degra et al. (2008) conducted the field experiment in Jaipur, Rajasthan, India. They revealed that plant height of pearl millet increased significantly due to 40 kg S ha⁻¹.
2.2.2 Yield and yield attributes

Sarkar et al. (1991) conducted an experiment on sandy loam soil on the effects of 0, 20, 40 or 60 kg S ha$^{-1}$ as potassium sulphate, single superphosphate or zinc sulphate on the yield of pearl millet cv. HHB 45. An application of potassium sulphate significantly increased dry matter yield and grain yield of pearl millet.

Gupta et al. (1993) revealed that an application of 20 mg S kg$^{-1}$ as calcium sulphate significantly increased dry matter yields in pearl millet.

Jat et al. (2002) studied the effects of S (0, 20, 40, and 60 kg ha$^{-1}$) rates on yield and quality of pearl millet cv. MH-179 in Jobner, Rajasthan, India, during the kharif season. They observed that an application of 40 kg S ha$^{-1}$ significantly increased grain, stover, and biological yields of pearl millet.

Sharma and Manohar (2002) conducted an experiment in Jaipur, Rajasthan, India, to study the effect of S (0, 20, 40, 60 and 80 kg ha$^{-1}$) on productivity of pearl. They stated that application of 40 kg S ha$^{-1}$ increased the grain and stover yields of pearl millet.

Chejara et al. (2003) conducted the field experiment on the effect of S on yield, quality, nutrient concentration and their uptake by pearl millet cv. HHB-67 in the loamy sand soil of Jobner, Rajasthan, India. The treatment consisted of 4 levels of S (0, 20, 40 and 60 kg ha$^{-1}$). They reported an increase in grain and stover yields with an application of 40 kg S ha$^{-1}$.

Dadhich and Gupta (2003) studied at semiarid eastern plain zone of Rajasthan, India on the productivity and economics of pearl millet fodder as influenced by sulphur. The treatments were 4 levels of S (0, 20, 40 and 60 kg ha$^{-1}$). They
revealed that an application of 40 kg S ha\textsuperscript{-1} significantly increased green and dry fodder yield.

Jat and Shaktawat (2003) studied an effect of S (0, 50 and 100 kg S ha\textsuperscript{-1}) on productivity of pearl millet cv. MH-179 in Rajasthan, India. They reported that an application of 100 kg S ha\textsuperscript{-1} recorded the highest grain and stover yield of pearl millet.

Sharma and Gupta (2003) conducted a field experiment on the effect of sulfur (0, 20, 40 and 60 kg ha\textsuperscript{-1}) on the growth and yield of pearl millet in Rajasthan, India during rainy season. They stated that an application of 40 kg S ha\textsuperscript{-1} significantly increased the growth and yield of pearl millet.

Dadhich and Gupta (2004) evaluated an effect of S (0, 20, 40 and 60 kg ha\textsuperscript{-1}) on plant morphology, fodder yield and nutrient content and uptake of fodder pearl millet under semiarid eastern plain zone of Rajasthan (India) at Jobner on a loamy sand soil. They revealed that an application of applied S up to 40 kg ha\textsuperscript{-1} significantly increased green fodder yield of pearl millet.

Yadav and Nand (2004) conducted the field experiments on pearl millet (hybrid HHB-67) in Gurgaon, Haryana, India to study the effect of site-specific nutrient management on crop yield. The highest pearl millet grain and stover yields were obtained with an application of 30 kg S ha\textsuperscript{-1}.

Degra \textit{et al.} (2008) reported that an application of sulphur @ 60 kg S ha\textsuperscript{-1} significantly increased yield of succeeding fodder pear millet.

\textbf{2.2.3 Quality parameters}

Jat \textit{et al.} (2002) studied the effect of S (0, 20, 40 and 60 kg ha\textsuperscript{-1}) rates on yield and quality of pearl millet cv. MH-179 in Jobner, Rajasthan, India, during the kharif season. They
stated that grain protein of pearl millet increased with an application of sulphur up to 40 kg ha\(^{-1}\).

Jakhar et al. (2003) reported that an application of 20 kg S ha\(^{-1}\) significantly increased the crude fibre and ether extract content at both the cuttings of pearl millet.

Sharma et al. (2004) revealed that S fertilizer application (60 kg ha\(^{-1}\)) significantly increased the chlorophyll and protein contents of seeds of pearl millet.

Dadhich and Gupta (2005) conducted a field experiment in Jobner, Rajasthan, India, on loamy sand soil during the consecutive summer seasons. They reported that an application of sulphur at 40 kg S ha\(^{-1}\) significantly increased crude protein of pearl millet.

Sheta et al. (2010) observed that an application of sulphur (40 kg S ha\(^{-1}\)) significantly increased crude protein content and crude protein yield of pearl millet.

2.2.4 Content and uptake of nutrients

Jat et al. (2002) studied the effect of S (0, 20, 40, and 60 kg ha\(^{-1}\)) rates on the yield and quality of pearl millet cv. MH-179 in Jobner, Rajasthan, India, during the kharif season. They revealed that an application of 40 kg S ha\(^{-1}\) significantly increased nutrient uptake by pearl millet.

Chejara et al. (2003) carried out a field experiment on an effect of S on yield, quality, nutrient concentration and their uptake by pearl millet cv. HHB-67 in the loamy sand soil of Jobner, Rajasthan, India. The treatment consisted 4 levels of S (0, 20, 40 and 60 kg ha\(^{-1}\)). The increasing S rates up to 40 kg ha\(^{-1}\) resulted in a significant increase in N, P and S content of grain and stover in pearl millet.
Jat and Shaktawat (2003) studied an effect of residual sulphur (S) on the productivity, economics and nutrient content of pearl millet at Fatehpur-Shekhawati (Sikar), Rajasthan, India and reported that residual S (100 kg ha\(^{-1}\)) significantly increased S content in pearl millet grain and stover.

Dadhich and Gupta (2004) evaluated the effect of S (0, 20, 40 and 60 kg ha\(^{-1}\)) on plant morphology, fodder yield and nutrient content and uptake of fodder pearl millet under semiarid eastern plain zone of Rajasthan (India), in Jobner on a loamy sand soil. The application of 40 kg S ha\(^{-1}\) significantly increased S content in plants.

Sharma et al. (2004) studied the quality and nutrient uptake of pearl millet cv. MH 169 as affected by sulfur fertilizer application (0, 20, 40 and 60 kg ha\(^{-1}\)). The N and S uptake significantly increased with increasing levels of S application (up to 40 kg S ha\(^{-1}\)) in pearl millet.

### 2.3 INTERACTION EFFECT OF POTASSIUM AND SULPHUR

Parashivamurthy and Gurumurthy (1995) studied the influence of potassium and sulphur on the yield of fodder maize in Alfisol. An application 60 kg K ha\(^{-1}\) with 20 kg S ha\(^{-1}\) significantly increased fodder yield of maize.

Varaviour and Mruthunjaya (1995) studied the response of fodder maize to potassium and sulphur in two soil series of south India. They recorded that Thyamagondlu series increased fodder yield up to 60 kg K with 20 kg S ha\(^{-1}\) and on Vijayapura soil, fodder yield increased up to 30 kg K with 10 kg S ha\(^{-1}\).
Yadav and Nand (2004) conducted the field experiments on pearl millet (hybrid HHB-67) in Gurgaon, Haryana, India, to study the effect of site-specific nutrient management on crop yield. The highest pearl millet grain and stover yields were obtained due to an application of 80 kg K ha$^{-1}$ with 30 kg S ha$^{-1}$.

Sheta et al. (2010) conducted the field experiment in Anand Agricultural University, Anand (Gujarat), India. They reported that an application of K (40 kg K$_2$O ha$^{-1}$) with S (40 kg S ha$^{-1}$) significantly increased crude protein content and crude protein yield of pearl millet.
A field experiment entitled “Effect of potato varietal on growth, yield and quality of summer potato plants” was carried out during the season 2011. The details of experimental materials used and techniques adopted during the course of the investigation are described in this chapter.
A field experiment entitled "Effect of potassium and sulphur on growth, yield and quality of summer pearl millet (Pennisetum glaucum L.)" was carried out during summer season of 2011. The details of experimental materials used, procedures followed and techniques adopted during the course of present investigation are described in this chapter.

3.1 EXPERIMENTAL SITE

The present experiment was carried out in C-6 block of the Instructional Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh during summer, 2011.

3.2 CLIMATE AND WEATHER

Junagadh is situated in South Saurashtra Agro-Climatic Zone of the Gujarat state. Geographically this place is located at 21.5° N latitudes and 70.5° E longitudes with an altitude of 60 meters above the mean sea level on the western side at the foothills of Mount Girnar. This place experiences the typical sub-tropical climate characterized by fairly cool and dry winter, hot and dry summer and moderately humid season.

The climate of Junagadh is sub-tropical. In general, the monsoon is warm and moderately humid. The winter is cold and dry. The annual precipitation ranges between 800 to 900 mm in normal years and exceeds 1000 mm during wet years. Winter set in the month of November and continues till the end of February. December is the coldest month of winter.
The weekly average weather data during the period of experimentation recorded at the Meteorological Observatory located at Instructional Farm, Department of Agronomy, Junagadh Agricultural University, Junagadh are presented in Table 3.1 and graphically depicted in Fig. 3.1.

### 3.3 PHYSICO-CHEMICAL PROPERTIES OF THE EXPERIMENTAL SITE

The experimental field had an even topography with a gentle slope. The soil samples were drawn from each replication of the experimental plot to a depth of 0-15 cm and 15-30 cm before sowing of experiment. The average values of composite soil samples are presented in Table 3.2. From data, it can be revealed that the soil was clayey in texture, medium in available nitrogen, phosphorus and potash and slightly alkaline in reaction with pH of 7.9.

### 3.4 CROPPING HISTORY OF THE EXPERIMENTAL PLOT

The cropping history of the experimental plot number C-6 of Instructional Farm, Junagadh Agricultural University, Junagadh for the preceding three years is presented in Table 3.3.

### 3.5 SALIENT FEATURES OF THE VARIETY

Newly hybrid pearl millet variety GHB-538 developed at Main Millet Research Station, Junagadh Agriculture University, Jamnagar and released in 2002. It has early maturity and temperature insensitivity for seed set under summer and pre-rabi seasons. It is also superior in grain yield (5003 kg/ha) under summer season over MH-169 (17.7 %) in North Gujarat
Table - 3.1: Mean weekly weather data during summer-2011

<table>
<thead>
<tr>
<th>Week No.</th>
<th>Temperature (°C)</th>
<th>Relative humidity (%)</th>
<th>Wind speed (km h⁻¹)</th>
<th>Bright sunshine (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Max.</td>
<td>Min.</td>
<td>Mean</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>30.3</td>
<td>15.8</td>
<td>23.05</td>
<td>75.6</td>
</tr>
<tr>
<td>8</td>
<td>30.1</td>
<td>14.3</td>
<td>22.2</td>
<td>64.3</td>
</tr>
<tr>
<td>9</td>
<td>33.5</td>
<td>16.0</td>
<td>24.75</td>
<td>60.1</td>
</tr>
<tr>
<td>10</td>
<td>34.3</td>
<td>18.4</td>
<td>26.35</td>
<td>52.9</td>
</tr>
<tr>
<td>11</td>
<td>38.4</td>
<td>17.2</td>
<td>27.8</td>
<td>47.9</td>
</tr>
<tr>
<td>12</td>
<td>36.6</td>
<td>19.2</td>
<td>27.9</td>
<td>84.0</td>
</tr>
<tr>
<td>13</td>
<td>38.5</td>
<td>20.6</td>
<td>29.55</td>
<td>59.3</td>
</tr>
<tr>
<td>14</td>
<td>37.5</td>
<td>21.7</td>
<td>29.6</td>
<td>49.6</td>
</tr>
<tr>
<td>15</td>
<td>39.2</td>
<td>23.3</td>
<td>31.25</td>
<td>66.7</td>
</tr>
<tr>
<td>16</td>
<td>39.6</td>
<td>23.2</td>
<td>31.4</td>
<td>73.3</td>
</tr>
<tr>
<td>17</td>
<td>40.6</td>
<td>23.8</td>
<td>32.2</td>
<td>72.6</td>
</tr>
<tr>
<td>18</td>
<td>37.8</td>
<td>24.8</td>
<td>31.3</td>
<td>81.3</td>
</tr>
<tr>
<td>19</td>
<td>37.8</td>
<td>25.5</td>
<td>31.65</td>
<td>81.0</td>
</tr>
<tr>
<td>20</td>
<td>38.6</td>
<td>26.0</td>
<td>32.3</td>
<td>85.0</td>
</tr>
<tr>
<td>21</td>
<td>36.8</td>
<td>26.8</td>
<td>31.8</td>
<td>80.0</td>
</tr>
<tr>
<td>22</td>
<td>38.6</td>
<td>27.0</td>
<td>32.8</td>
<td>78.0</td>
</tr>
<tr>
<td>23</td>
<td>39.9</td>
<td>27.4</td>
<td>33.65</td>
<td>79.1</td>
</tr>
</tbody>
</table>
Fig. 3.1. Mean weekly weather data during summer - 2011
Table - 3.2 : Physico-chemical properties of the experimental site

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Value at 0-15 cm</th>
<th>Value at 15-30 cm</th>
<th>Method followed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>A) Mechanical composition</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Sand (%)</td>
<td>22.56</td>
<td>21.54</td>
<td></td>
</tr>
<tr>
<td>2. Silt (%)</td>
<td>13.71</td>
<td>13.37</td>
<td>International pipette method (Piper, 1950)</td>
</tr>
<tr>
<td>3. Clay (%)</td>
<td>63.73</td>
<td>64.05</td>
<td></td>
</tr>
<tr>
<td>Textural class</td>
<td>Clayey</td>
<td>Clayey</td>
<td></td>
</tr>
<tr>
<td><strong>B) Chemical composition</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Soil pH</td>
<td>8.00</td>
<td>7.90</td>
<td>pH meter (Richards, 1954)</td>
</tr>
<tr>
<td>2. Electrical conductivity (1:2.5) in dS m⁻¹</td>
<td>0.33</td>
<td>0.32</td>
<td>EC meter (Jackson, 1974)</td>
</tr>
<tr>
<td>3. Organic carbon (%)</td>
<td>0.83</td>
<td>0.79</td>
<td>Walkley and Black’s method (Jackson, 1974)</td>
</tr>
<tr>
<td>4. Available N (kg ha⁻¹)</td>
<td>267.0</td>
<td>252.0</td>
<td>Alkaline KMnO₄ method (Subbaiah and Asija, 1956)</td>
</tr>
<tr>
<td>5. Available P₂O₅ (kg ha⁻¹)</td>
<td>38.3</td>
<td>36.4</td>
<td>Olsen’s method (Olsen et al., 1954)</td>
</tr>
<tr>
<td>6. Available K₂O (kg ha⁻¹)</td>
<td>232.00</td>
<td>225.00</td>
<td>Flame Photometric method (Jackson, 1974)</td>
</tr>
</tbody>
</table>
Table - 3.3 : Cropping history of the experimental plot

<table>
<thead>
<tr>
<th>Year</th>
<th>Season</th>
<th>Crop</th>
<th>Fertilizer (kg ha(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>N</td>
</tr>
<tr>
<td>2008-2009</td>
<td>Summer</td>
<td>Fallow</td>
<td></td>
</tr>
<tr>
<td>Kharif</td>
<td></td>
<td>Black gram</td>
<td>20</td>
</tr>
<tr>
<td>Rabi</td>
<td></td>
<td>Mustard</td>
<td>50</td>
</tr>
<tr>
<td>2009-2010</td>
<td>Summer</td>
<td>Fallow</td>
<td></td>
</tr>
<tr>
<td>Kharif</td>
<td></td>
<td>Castor</td>
<td>100</td>
</tr>
<tr>
<td>Rabi</td>
<td></td>
<td>Castor</td>
<td></td>
</tr>
<tr>
<td>2010-2011</td>
<td>Summer</td>
<td>Fallow</td>
<td></td>
</tr>
<tr>
<td>Kharif</td>
<td></td>
<td>Soybean</td>
<td>20</td>
</tr>
<tr>
<td>Rabi</td>
<td></td>
<td>Fallow</td>
<td></td>
</tr>
<tr>
<td>2011-12</td>
<td>Summer</td>
<td>Pearl millet</td>
<td>120</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Present</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>investigation)</td>
<td></td>
</tr>
</tbody>
</table>
and Saurashtra and under pre-rabi condition over GHB-526 (8.7\% in Saurashtra. It has high level of resistance to downey mildew and pests of pearl millet. The hybrid GHB-538 is endorsed for cultivation for summer/pre-rabi pearl millet growing areas of North Gujarat and Saurashtra region (Table: 3.4).

Table - 3.4 : Characteristics of pearl millet cultivar GHB-538

<table>
<thead>
<tr>
<th>1) Parents</th>
<th>Female-95222A X Male- J-2372</th>
</tr>
</thead>
<tbody>
<tr>
<td>2) Year of release</td>
<td>2002</td>
</tr>
<tr>
<td>3) Evolved at</td>
<td>Main Millet Research Station, JAU, Jamnagar.</td>
</tr>
<tr>
<td>4) Plant habit:</td>
<td></td>
</tr>
<tr>
<td>i) Plant height</td>
<td>175-185 cm</td>
</tr>
<tr>
<td>ii) Days to 50% flowering</td>
<td>46-49</td>
</tr>
<tr>
<td>iii) Days to maturity</td>
<td>85-90</td>
</tr>
<tr>
<td>iv) Ear head length</td>
<td>22-27 cm</td>
</tr>
<tr>
<td>v) Earhead girth</td>
<td>9-11 cm</td>
</tr>
<tr>
<td>vi) Effective tillers/plant</td>
<td>4-6</td>
</tr>
<tr>
<td>vii) Anther colour</td>
<td>Cream</td>
</tr>
<tr>
<td>viii) Ear head shape</td>
<td>Conical</td>
</tr>
<tr>
<td>ix) Grain colour</td>
<td>Light brownish gray</td>
</tr>
<tr>
<td>x) Grain shape</td>
<td>Globule</td>
</tr>
<tr>
<td>5) 1000 grain weight</td>
<td>9.27 gm</td>
</tr>
<tr>
<td>6) Grain yield (kg/ha)</td>
<td>4711</td>
</tr>
<tr>
<td>7) Fodder yield (kg/ha)</td>
<td>8400</td>
</tr>
</tbody>
</table>
3.6 EXPERIMENTAL DETAILS

The details of the experimental techniques employed for the investigation on “Effect of potassium and sulphur on growth, yield and quality of summer pearl millet (Pennisetum glaucum L.)” are described below.

3.6.1 Treatment details

Total 16 treatment combinations comprising of four levels each of potassium and sulphur are as given below (Table 3.5).

A) Potassium (kg ha$^{-1}$) : 4 levels

1) Control (K$_1$)

2) 60 kg ha$^{-1}$ (K$_2$)

3) 90 kg ha$^{-1}$ (K$_3$)

4) 120 kg ha$^{-1}$ (K$_4$)

B) Sulphur (kg ha$^{-1}$) : 4 levels

1) Control (S$_1$)

2) 20 kg/ha (S$_2$)

3) 30 kg/ha (S$_3$)

4) 40 kg/ha (S$_4$)
Table 3.5: Details of treatment combinations

<table>
<thead>
<tr>
<th>Treatment No.</th>
<th>Potassium (Kg ha⁻¹)</th>
<th>Sulphur (kg ha⁻¹)</th>
<th>Code Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>T₁</td>
<td>0</td>
<td>0</td>
<td>K₁S₁</td>
</tr>
<tr>
<td>T₂</td>
<td>0</td>
<td>20</td>
<td>K₁S₂</td>
</tr>
<tr>
<td>T₃</td>
<td>0</td>
<td>30</td>
<td>K₁S₃</td>
</tr>
<tr>
<td>T₄</td>
<td>0</td>
<td>40</td>
<td>K₁S₄</td>
</tr>
<tr>
<td>T₅</td>
<td>60</td>
<td>0</td>
<td>K₂S₁</td>
</tr>
<tr>
<td>T₆</td>
<td>60</td>
<td>20</td>
<td>K₂S₂</td>
</tr>
<tr>
<td>T₇</td>
<td>60</td>
<td>30</td>
<td>K₂S₃</td>
</tr>
<tr>
<td>T₈</td>
<td>60</td>
<td>40</td>
<td>K₂S₄</td>
</tr>
<tr>
<td>T₉</td>
<td>90</td>
<td>0</td>
<td>K₃S₁</td>
</tr>
<tr>
<td>T₁₀</td>
<td>90</td>
<td>20</td>
<td>K₃S₂</td>
</tr>
<tr>
<td>T₁₁</td>
<td>90</td>
<td>30</td>
<td>K₃S₃</td>
</tr>
<tr>
<td>T₁₂</td>
<td>90</td>
<td>40</td>
<td>K₃S₄</td>
</tr>
<tr>
<td>T₁₃</td>
<td>120</td>
<td>0</td>
<td>K₄S₁</td>
</tr>
<tr>
<td>T₁₄</td>
<td>120</td>
<td>20</td>
<td>K₄S₂</td>
</tr>
<tr>
<td>T₁₅</td>
<td>120</td>
<td>30</td>
<td>K₄S₃</td>
</tr>
<tr>
<td>T₁₆</td>
<td>120</td>
<td>40</td>
<td>K₄S₄</td>
</tr>
</tbody>
</table>

3.6.2 EXPERIMENTAL DESIGN AND LAYOUT

The experiment was laid out in Factorial Randomized Block Design (FRBD) with three replications. The layout plan is given in (Fig. 3.2).
Design: - Randomized Block Design (Factorial)

Plot Size: - Gross Plot: 5.0 m x 3.6 m
Net Plot: 4.0 m x 2.4 m
Replications: 3
Spacing: 60 cm x 10 cm

Fig: - 3.2 Plan of Layout
3.6.3 Details of Layout

Number of replication: Three
Design: FRBD
Number of treatment combination: 16
Total number of plots: 48
Spacing: 60 cm x 10 cm
Plot size:
(a) Gross plot size: 3.60 m x 5.00 m
(b) Net-plot: 2.40 m x 4.00 m
Seed rate: 4.0 kg ha\(^{-1}\)
Crop and Variety: Pearl millet, GHB-538
Year and season of commencement: 2011, Summer
Fertilizer: 120 kg N + 60 kg P\(_2\)O\(_5\) ha\(^{-1}\)

3.7 Schedule of Cultural Operations

A schedule of cultural operations followed during the entire crop season is presented in Table 3.6.

3.7.1 Land Preparation

The experimental field was prepared by one ploughing followed by harrowing and planking. Finally, the field was levelled with the help of leveler to provide gentle slope. After proper field conditions, furrows were opened and followed by layout preparation just to keep field ready for sowing. The layout was done as per the design employed.

3.7.2 Fertilization

The lines were drawn by marker in each plot keeping spacing of 60 cm in between two rows and furrows were opened by *Kudali*. Full dose of phosphorus (60 kg P\(_2\)O\(_5\) ha\(^{-1}\)) through single super phosphate and 50 % nitrogen (60 kg N ha\(^{-1}\)) from
<table>
<thead>
<tr>
<th>Field operation</th>
<th>Frequency</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A) Pre-sowing operations</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tractor ploughing</td>
<td>1</td>
<td>9-02-2011</td>
</tr>
<tr>
<td>Harrowing</td>
<td>2</td>
<td>11-02-2011</td>
</tr>
<tr>
<td>Planking</td>
<td>1</td>
<td>11-02-2011</td>
</tr>
<tr>
<td>Opening of furrows</td>
<td>1</td>
<td>14-02-2011</td>
</tr>
<tr>
<td>Field layout</td>
<td>1</td>
<td>15-02-2011</td>
</tr>
<tr>
<td>Fertilization (basal)</td>
<td>1</td>
<td>18-02-2011</td>
</tr>
<tr>
<td><strong>B) Sowing and fertilizer application</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Application of fertilizers (as per treatments)</td>
<td>1</td>
<td>18-02-2011</td>
</tr>
<tr>
<td>Sowing</td>
<td>1</td>
<td>18-02-2011</td>
</tr>
<tr>
<td><strong>C) Post-sowing operations</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thinning and gap filling</td>
<td>1</td>
<td>08-03-2011</td>
</tr>
<tr>
<td>Irrigations</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>18-02-2011</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>28-02-2011</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>11-03-2011</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>23-03-2011</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>06-04-2011</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>20-04-2011</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>02-05-2011</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>12-05-2011</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>24-05-2011</td>
</tr>
<tr>
<td>Hand weeding</td>
<td>1</td>
<td>05-03-2011</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20-03-2011</td>
</tr>
<tr>
<td>Interculturing with hand hoe</td>
<td>2</td>
<td>06-04-2011</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Top dressing of nitrogen</td>
<td>1</td>
<td>12-03-2011</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>08-04-2011</td>
</tr>
<tr>
<td>Harvesting</td>
<td>1</td>
<td>02-06-2011</td>
</tr>
<tr>
<td>Threshing and winnowing</td>
<td>1</td>
<td>11-06-2011</td>
</tr>
</tbody>
</table>
urea were applied in furrows before sowing. Remaining 50% nitrogen (60 kg N/ha) was applied in the form of urea in two equal splits at an interval of 20-25 days during the experimentation.

Entire quantity of potassium through muriate of potash and sulphur from gypsum were applied as per treatment at the time of sowing.

3.7.3 Sowing of crop

The seeds treated with thirum at the rate of 3 g kg⁻¹ seeds were sown manually in the open furrows of each plot at 3 cm depth and covered with soil.

3.8 POST SOWING OPERATIONS

3.8.1 Gap Filling and Thinning

Gap filling and thinning were done at 20 days after sowing in each plot mainly for the purpose of the maintaining uniform plant stand in experimental plots.

3.8.2 Weeding and Interculturing

Attempts were made to keep the experimental field weed free throughout the crop season. Two interculturings and two hand weedings were carried out during the entire crop growth period.

3.8.3 Plant Protection Measures

No incidence of any serious insect-pests or diseases was observed during the crop period and hence no plant protection measures required to be taken.
3.9 **IRRIGATION**

The first irrigation was given just after sowing of the seeds. Total nine irrigations were applied during the crop growth period as and when required by crop depending upon weather situation.

3.10 **HARVESTING AND THRESHING**

The crop was harvested when sign of maturity was observed. The net experimental area was marked with nylon thread and ring lines were harvested first and removed from the experimental plot. Then the net plot was harvested by nipping earheads. Later the plants were cut for fodder yield. Earheads were kept plot wise in separate gunny bags. After complete drying, they were threshed and cleaned. The grain weight per plot was recorded on the same day.

3.11 **BIOMETRIC OBSERVATIONS**

The biometric observations were recorded from five randomly selected plants tagged within each net plot. The details of various growth parameters and yield attributes studied during the course of investigation are given in Table 3.7. Details of the techniques employed for recording observations are described below.

3.11.1 **Plant Population**

Plant population at initial (15 DAS) and at harvest was recorded by counting the number of plants per meter row length and converted on hectare basis.
Table - 3.7: Biometric observations recorded during investigation

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Characters</th>
<th>Sample size</th>
<th>Time of recording</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Plant population</td>
<td>Net plot area</td>
<td>Initial and at harvest</td>
</tr>
<tr>
<td>2</td>
<td>Plant height (cm)</td>
<td>Five plants from net plot</td>
<td>30, 60 days after sowing and at harvest</td>
</tr>
<tr>
<td>3</td>
<td>Number of total tillers per plant</td>
<td>Five plants from net plot</td>
<td>At harvest</td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Number of effective tillers per plant</td>
<td>Five plants from net plot</td>
<td>At harvest</td>
</tr>
<tr>
<td>5</td>
<td>Earhead length (cm)</td>
<td>Five plants from net plot</td>
<td>At harvest</td>
</tr>
<tr>
<td>6</td>
<td>Earhead girth (cm)</td>
<td>Five plants from net plot</td>
<td>At harvest</td>
</tr>
<tr>
<td>7</td>
<td>Test weight (g)</td>
<td>Weight of 1000 grains from net plot</td>
<td>After harvest</td>
</tr>
<tr>
<td>8</td>
<td>Grain yield (kg ha⁻¹)</td>
<td>Net plot area</td>
<td>After harvest</td>
</tr>
<tr>
<td>9</td>
<td>Fodder yield (kg ha⁻¹)</td>
<td>Net plot area</td>
<td>After harvest</td>
</tr>
<tr>
<td>10</td>
<td>Grain: fodder ratio</td>
<td>Net plot area</td>
<td>After harvest</td>
</tr>
</tbody>
</table>
3.11.2 Growth Parameters

3.11.2.1 Plant height (cm)

Plant height was recorded at 30, 60 DAS and at harvest for five randomly selected tagged plants in each net plot and average was calculated and recorded separately.

3.11.2.2 Number of total tillers per plant

At harvest, the total number of tillers per plant was counted from randomly selected five tagged plants in each treatment and finally average total tillers in each treatment was worked out and recorded separately.

3.11.3 Yield attributes

3.11.3.1 Effective tillers per plant

Number of effective tillers per plant was recorded from the same site from where number of total tillers per plant was counted.

3.11.3.2 Earhead length (cm)

The earheads from the same randomly tagged five plants were used for studying this character. Length of five earheads was measured in centimeter from the cut end of the earhead to the tip of the earhead and mean was worked out and recorded plot wise.

3.11.3.3 Earhead girth (cm)

Top, middle and bottom earhead girth was measured by vernier calipers and mean value was computed treatment wise for each earhead.
3.11.3.4 Test weight (1000 grains weight)

A composite sample of grains was collected from the produce of each net plot and 1000 grains were counted and their weight was recorded in gram by using electric balance.

3.11.3.5 Grain Yield (kg ha⁻¹)

From the net plot, ear heads were nipped, threshed and cleaned separately from each net plot. Finally, the yield obtained from net plot was converted in to kg ha⁻¹ and recorded.

3.11.3.6 Fodder Yield (kg ha⁻¹)

After harvesting and nipping, the fodder from each net plot was allowed to sun dry separately for few days and the weight of sun dried fodder was recorded and converted on hectare basis.

3.11.3.7 Grain: Fodder ratio

It was computed from grain and fodder yields of net plots by using following formula.

\[
\text{Grain: fodder ratio} = \frac{\text{Grain yield (kg ha}^{-1}\text{)}}{\text{Fodder yield (kg ha}^{-1}\text{)}}
\]

3.12 BIOCHEMICAL ANALYSIS

3.12.1 Protein content

The percentage protein of grains was worked out by multiplying the nitrogen values with a factor of 6.25 as reported by Gupta et al. (1972).
3.12.2 Oil content

Oil content (%) was determined by using Nuclear Magnetic Resonance (NMR) method as suggested by Tiwari et al. (1974).

3.13 CHEMICAL ANALYSIS

Chemical analysis pertaining to nutrients content and uptake by grain and fodder was carried out as described below.

Representative samples of grains and fodder of pearl millet were drawn from each net plot produce after harvesting for chemical studies. The samples were oven dried at 70°C to constant weight for 24 hours and powdered by mechanical willy grinder. Then samples were analyzed for estimation of nitrogen, phosphorus, potassium and sulphur contents. The methods used for determination of various elements from plant materials are as under

3.13.1 PLANT ANALYSIS

3.13.1.1 Nitrogen content and uptake (kg ha⁻¹)

Nitrogen (N) content in grain and fodder was determined on present dry weight bases as per the method of modified Kjeldhal as described by Jackson (1974). The uptake of nitrogen by grain and fodder of pearl millet crop in kg ha⁻¹ was calculated by using following formula.

\[
\text{Nitrogen uptake by grain/fodder (kg ha}^{-1}) = \frac{\text{Nitrogen content in grain/fodder (}% \times \text{Grain/Fodder Yield (kg ha}^{-1})}{100}
\]
3.13.1.2 Phosphorus content and uptake (kg ha\(^{-1}\))

Respective samples of grain and fodder were taken at maturity from each net plot for the estimation of phosphorus. The digestion of sample was done as per method No.54 of USDA (1954), Hand book No. 60 using nitric acid and perchloric acid. Phosphorus was determined by vanedo-molybdo phosphoric acid yellow color method (Jackson, 1974). The uptake of phosphorus by grain and fodder of pearl millet was calculated by using the following formula.

\[
\text{Phosphorus uptake by grain/fodder (kg ha}^{-1}) = \frac{\text{Phosphorus content in grain/ Fodder (%) x Grain/Fodder Yield (kg ha}^{-1})}{100}
\]

3.13.1.3 Potassium content and uptake (kg ha\(^{-1}\))

Respective samples of grain and fodder were taken at maturity from each net plot for the estimation of potassium. The potassium (K) content in grain and fodder was determined as per the method of Flame Photometer method (Jackson, 1974). The uptake of potassium by grain and fodder of pearl millet was calculated by using the formula as under.

\[
\text{Potassium uptake by grain/ Fodder (kg ha}^{-1}) = \frac{\text{Potassium content in grain/Fodder (%) x Grain/Fodder Yield (kg ha}^{-1})}{100}
\]

3.13.1.4 Sulphur content and uptake (kg ha\(^{-1}\))

Sulphur was determined by turbidometric method as described by Chaudhry and Cornfield, (1966). The uptake of
sulphur by grain and fodder of pearl millet was calculated by using the following formula.

\[
\text{Sulphur uptake by grain/ Fodder} = \left( \frac{\text{Sulphur content in grain/Fodder (kg ha}^{-1}) \times \frac{\text{Grain/ Fodder Yield (kg ha}^{-1})}{100}}{\text{(kg ha}^{-1})} \right)
\]

3.13.2 SOIL ANALYSIS

i. Nitrogen status in soil before sowing and after harvesting (kg ha\(^{-1}\))

Estimation of available N content in soil was carried out by Alkaline KMnO\(_4\) method as described by Subbaiah and Asija (1956).

ii. Phosphorus status in soil before sowing and after harvesting (kg ha\(^{-1}\))

Phosphorus was determined by Olsen’s method described by Olsen’s et al. (1954).

iii. Potassium status in soil before sowing and after harvesting (kg ha\(^{-1}\))

Potassium was determined by Flame Photometric method by Jackson (1974).

iv. Sulphur status in soil before sowing and after harvesting (kg ha\(^{-1}\))

Sulphur was be determined by Turbidometric method as described by Chaudhry and Cornfield, (1966).
3.14 STATISTICAL ANALYSIS

The observations recorded for growth parameters, yield and other characters were put to statistical analysis in accordance with the analysis of variance techniques as suggested by Fisher (1950) for randomized block design (factorial). The critical differences were calculated to assess the significance of treatment mean whenever the ‘F’ test was found significant at 5% levels of probability. To elucidate the nature and the magnitude of effects, treatment summary tables along with S.Em.± and C.D. were prepared and are given in the text of chapter “Experimental Results” and their analysis of variance are given in the appendices at the end. All these statistical estimates were computed by standard statistical procedure (Panse and Sukhatme, 1985).

3.15 ECONOMICS

In order to evaluate the effectiveness of each individual treatment, the relative economics of each treatment combination was worked out in terms of net profit so that the most effective and remunerative treatment combination could be found out.

The gross realization in terms of rupees per hectare was worked out taking into consideration the grain and fodder yields of each treatment combination and their prevailing market price during the month of June 2011. Likewise, cost of cultivation was worked out by considering the expenses incurred for cultivation operations from preparatory tillage to harvesting including threshing, cleaning as well as cost of inputs viz., seeds, fertilizers and irrigation applied to each treatment.
The net realization was worked out by deducting the total cost of cultivation from the gross realization per hectare for each treatment combination and recorded accordingly.

The benefit: cost ratio (BCR) was calculated by using the following formula:

\[
BCR = \frac{\text{Gross realization (Rs ha}^{-1})}{\text{Total cost of cultivation (Rs ha}^{-1})}
\]
EXPERIMENTAL RESULTS
IV. EXPERIMENTAL RESULTS

The results of the field experiment entitled “Effect of potassium and sulphur on growth, yield and quality of summer pearl millet [Pennisetum glaucum (L.)]” conducted at the Instructional Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh during the summer season of 2011 are presented in this chapter along with the statistical inferences. The details pertaining to growth parameters, yield attributes and yield, quality parameters, nutrient content and uptake and available nutrients in soil after harvest of crop were subjected to statistical analysis and their analyses of variance are given in the Appendices I to X with the levels of significance. The results have also been depicted graphically wherever it is necessary. All findings pertaining to main effects and only significant interactions described here under in the following heads.

4.1 GROWTH PARAMETERS
4.2 YIELD ATTRIBUTES AND YIELD
4.3 QUALITY PARAMETERS
4.4 NUTRIENT CONTENT
4.5 NUTRIENT UPTAKE
4.6 NUTRIENT STATUS OF SOIL AFTER HARVEST
4.7 ECONOMICS

4.1 GROWTH PARAMETER
4.1.1 Plant population

The data pertaining to plant population at initial and at harvest (final) as influenced by various treatments are given in
Table 4.1 and their analysis of variance is furnished in Appendix I.

The results indicated that neither the individual treatments nor their interactions had significant influence on plant population at initial and at harvest stage. It indicates that potassium and sulphur did not affect the germination of the pearl millet and also plant population remained uniform at harvest.

4.1.2 Plant height

The data on periodical plant height (cm) at 30, 60 DAS and at harvest as influenced by various treatments viz., potassium and sulphur levels are presented in Table 4.2 and their analysis of variance is given in Appendix I. Periodical plant height is also graphically depicted in Fig. 4.1.

4.1.2.1 Effect of potassium

The results depicted in Table 4.2 with regard to plant height recorded at 30, 60 DAS and at harvest indicated that difference due to various levels of potassium was found significant. Treatment $K_4$ (120 kg K$_2$O ha$^{-1}$) recorded significantly higher plant height (28.4, 133.3 and 156.9 cm at 30, 60 DAS and at harvest, respectively) but it remained at par with treatment $K_3$ (90 kg K$_2$O ha$^{-1}$). While treatment $K_1$ (Control) recorded significantly the lowest plant height (24.0, 90.8 and 114.4 cm at 30, 60 DAS and at harvest, respectively).

4.1.2.2 Effect of sulphur

The data presented in Table 4.2 revealed that effect of various levels of sulphur has significantly influenced the plant height recorded at 30, 60 DAS and at harvest. Treatment $S_4$
Table - 4.1: Initial and final plant population of pearl millet as influenced by different levels of potassium and sulphur

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Initial plant population (plants ha(^{-1}))</th>
<th>Final plant population (plants ha(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potassium (kg K(_2)O ha(^{-1}))</td>
<td></td>
<td></td>
</tr>
<tr>
<td>K(_1) - 0</td>
<td>166474</td>
<td>166129</td>
</tr>
<tr>
<td>K(_2) - 60</td>
<td>166465</td>
<td>166120</td>
</tr>
<tr>
<td>K(_3) - 90</td>
<td>166524</td>
<td>166179</td>
</tr>
<tr>
<td>K(_4) - 120</td>
<td>166437</td>
<td>166092</td>
</tr>
<tr>
<td>S.Em.±</td>
<td>915</td>
<td>887</td>
</tr>
<tr>
<td>C.D. at 5 %</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Sulphur (kg S ha(^{-1}))</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S(_1) - 0</td>
<td>166332</td>
<td>165987</td>
</tr>
<tr>
<td>S(_2) - 20</td>
<td>166512</td>
<td>166167</td>
</tr>
<tr>
<td>S(_3) - 30</td>
<td>166558</td>
<td>166213</td>
</tr>
<tr>
<td>S(_4) - 40</td>
<td>166497</td>
<td>166152</td>
</tr>
<tr>
<td>S.Em.±</td>
<td>915</td>
<td>887</td>
</tr>
<tr>
<td>C.D. at 5 %</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>C.V. %</td>
<td>1.90</td>
<td>1.85</td>
</tr>
<tr>
<td>Interaction K X S</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>
Table - 4.2: Plant height of pearl millet at 30, 60 DAS and at harvest as influenced by different levels of potassium and sulphur levels

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Plant height (cm)</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30 DAS</td>
<td>60 DAS</td>
<td>At harvest</td>
<td></td>
</tr>
<tr>
<td><strong>Potassium (kg K\textsubscript{2}O ha\textsuperscript{-1})</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K\textsubscript{1} - 0</td>
<td>24.0</td>
<td>90.8</td>
<td>114.4</td>
<td></td>
</tr>
<tr>
<td>K\textsubscript{2} - 60</td>
<td>26.3</td>
<td>106.8</td>
<td>130.4</td>
<td></td>
</tr>
<tr>
<td>K\textsubscript{3} - 90</td>
<td>26.8</td>
<td>127.4</td>
<td>151.1</td>
<td></td>
</tr>
<tr>
<td>K\textsubscript{4} - 120</td>
<td>28.4</td>
<td>133.3</td>
<td>156.9</td>
<td></td>
</tr>
<tr>
<td>S.Em.±</td>
<td>0.58</td>
<td>4.01</td>
<td>4.09</td>
<td></td>
</tr>
<tr>
<td>C.D. at 5 %</td>
<td>1.69</td>
<td>11.57</td>
<td>11.80</td>
<td></td>
</tr>
<tr>
<td><strong>Sulphur (kg S ha\textsuperscript{-1})</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S\textsubscript{1} - 0</td>
<td>24.0</td>
<td>92.1</td>
<td>115.7</td>
<td></td>
</tr>
<tr>
<td>S\textsubscript{2} - 20</td>
<td>26.4</td>
<td>112.8</td>
<td>136.5</td>
<td></td>
</tr>
<tr>
<td>S\textsubscript{3} - 30</td>
<td>26.8</td>
<td>122.1</td>
<td>145.7</td>
<td></td>
</tr>
<tr>
<td>S\textsubscript{4} - 40</td>
<td>28.3</td>
<td>131.3</td>
<td>154.9</td>
<td></td>
</tr>
<tr>
<td>S.Em.±</td>
<td>0.58</td>
<td>4.01</td>
<td>4.09</td>
<td></td>
</tr>
<tr>
<td>C.D. at 5 %</td>
<td>1.69</td>
<td>11.57</td>
<td>11.80</td>
<td></td>
</tr>
<tr>
<td>C.V. %</td>
<td>7.86</td>
<td>12.11</td>
<td>10.24</td>
<td></td>
</tr>
<tr>
<td><strong>Interaction</strong></td>
<td><strong>K X S</strong></td>
<td><strong>NS</strong></td>
<td><strong>NS</strong></td>
<td><strong>NS</strong></td>
</tr>
</tbody>
</table>

Experimental results

44
Fig. 4.1: Plant height of pearl millet at 30, 60 DAS and at harvest as influenced by different levels of potassium and sulphur levels.
recorded significantly higher plant height (28.3, 131.3 and 154.9 cm at 30, 60 DAS and at harvest, respectively) but it remained at par with treatment S₃ (30 kg S ha⁻¹). Whereas treatment S₁ (Control) produced the shortest plants (24.0, 92.1 and 115.7 cm at 30, 60 DAS and at harvest, respectively).

4.1.2.3 Interaction Effect

The interaction effect of potassium and sulphur levels on plant height at 30, 60 DAS and at harvest was found non-significant.

4.1.3 Number of total tillers per plant

The data regarding total tillers per plant as affected by potassium and sulphur levels are summarized in Table 4.3, their analysis of variance is given in Appendix II and graphically illustrated in Fig. 4.2.

4.1.3.1 Effect of potassium

The results showed in Table 4.3 indicated that treatment K₄ (120 kg K₂O ha⁻¹) produced significantly more number of total tillers per plant (4.09) as compared to treatment K₁ (Control) which recorded significantly the minimum number of total tillers per plant (3.62).

4.1.3.2 Effect of sulphur

A perusal of data presented in Table 4.3 showed that treatment S₄ (40 kg S ha⁻¹) recorded significantly more number of tillers per plant (4.08) than treatment S₁ (Control) which recorded significantly the minimum number of total tillers per plant (3.61).
Table 4.3: Number of total tillers per plant and effective tillers per plant as influenced by different levels of potassium and sulphur at harvest

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Number of total tillers per plant</th>
<th>Number of effective tillers per plant</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Potassium (kg K₂O ha⁻¹)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K₁ - 0</td>
<td>3.62</td>
<td>2.30</td>
</tr>
<tr>
<td>K₂ - 60</td>
<td>3.87</td>
<td>2.52</td>
</tr>
<tr>
<td>K₃ - 90</td>
<td>3.93</td>
<td>2.58</td>
</tr>
<tr>
<td>K₄ - 120</td>
<td>4.09</td>
<td>2.74</td>
</tr>
<tr>
<td>S.Em.±</td>
<td>0.08</td>
<td>0.07</td>
</tr>
<tr>
<td>C.D. at 5 %</td>
<td>0.23</td>
<td>0.20</td>
</tr>
<tr>
<td><strong>Sulphur (kg S ha⁻¹)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S₁ - 0</td>
<td>3.61</td>
<td>2.30</td>
</tr>
<tr>
<td>S₂ - 20</td>
<td>3.88</td>
<td>2.53</td>
</tr>
<tr>
<td>S₃ - 30</td>
<td>3.93</td>
<td>2.58</td>
</tr>
<tr>
<td>S₄ - 40</td>
<td>4.08</td>
<td>2.73</td>
</tr>
<tr>
<td>S.Em.±</td>
<td>0.08</td>
<td>0.07</td>
</tr>
<tr>
<td>C.D. at 5 %</td>
<td>0.23</td>
<td>0.20</td>
</tr>
<tr>
<td>C.V. %</td>
<td>7.00</td>
<td>9.51</td>
</tr>
<tr>
<td><strong>Interaction K X S</strong></td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>
Fig. 4.2 Number of total tillers per plant and effective tillers per plant as influenced by different levels of potassium and sulphur at harvest
4.1.3.3 Interaction effect

The interaction effect of potassium and sulphur was found non significant with regards to total number of tillers per plant.

4.2 YIELD ATTRIBUTES AND YIELD

4.2.1 Number of effective tillers per plant

Data on the number of effective tillers per plant as influenced by different levels of potassium and sulphur are presented in Table 4.3 and their analysis of variance is given in Appendix II. The data are also graphically illustrated in Fig. 4.2.

4.2.1.1 Effect of potassium

An appraisal of data presented in Table 4.3 showed that significantly more number of effective tillers per plant (2.74) was recorded under treatment $K_4$ (120 kg $K_2O$ ha$^{-1}$) but it was statistically at par with treatment $K_3$ (90 kg $K_2O$ ha$^{-1}$). Whereas treatment $K_1$ (Control) produced significantly the minimum number of total tillers per plant (2.30).

4.2.1.2 Effect of sulphur

The data presented in Table 4.3 revealed that treatment $S_4$ (40 kg S ha$^{-1}$) produced significantly more number of effective tillers per plant (2.73) but it was at par with treatment $S_3$ (30 kg S ha$^{-1}$). Whereas treatment $S_1$ (Control) recorded significantly the minimum number of effective tillers per plant (2.30).
4.2.1.3 Interaction effect

The interaction effect of potassium and sulphur was found non-significant for number of effective tillers per plant.

4.2.2 Earhead length

The data pertaining to earhead length (cm) as affected by various levels of potassium and sulphur are given in Table 4.4 and their analysis of variance is given in Appendix II. The data are also graphically illustrated in Fig.4.3.

4.2.2.1 Effect of potassium

The perusal of data presented in Table 4.4 further revealed that significantly the highest earhead length (25.03 cm) was noted under treatment K₄ (120 kg K₂O ha⁻¹) whereas significantly the lowest earhead length (20.66 cm) was noted under treatment K₁ (Control).

4.2.2.2 Effect of sulphur

An appraisal of data presented Table 4.4 showed that treatment S₄ (40 kg S ha⁻¹) recorded significantly the highest earhead length (24.94 cm) while treatment S₁ (Control) obtained significantly the lowest earhead length (20.63 cm).

4.2.2.3 Interaction effect

The interaction effect of potassium and sulphur did not show any significance with respect to earhead length.

4.2.3 Earhead girth

Data on earhead girth (cm) as affected by various levels of potassium and sulphur are summarized in Table 4.4.
Table 4.4: Earhead length and girth as influenced by different levels of potassium and sulphur at harvest

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Earhead length (cm)</th>
<th>Earhead girth (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Potassium (kg K₂O ha⁻¹)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K₁ - 0</td>
<td>20.66</td>
<td>2.84</td>
</tr>
<tr>
<td>K₂ - 60</td>
<td>22.88</td>
<td>3.06</td>
</tr>
<tr>
<td>K₃ - 90</td>
<td>23.45</td>
<td>3.12</td>
</tr>
<tr>
<td>K₄ - 120</td>
<td>25.03</td>
<td>3.28</td>
</tr>
<tr>
<td>S.Em.±</td>
<td>0.48</td>
<td>0.07</td>
</tr>
<tr>
<td>C.D. at 5 %</td>
<td>1.38</td>
<td>0.20</td>
</tr>
<tr>
<td><strong>Sulphur (kg S ha⁻¹)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S₁ - 0</td>
<td>20.63</td>
<td>2.84</td>
</tr>
<tr>
<td>S₂ - 20</td>
<td>23.01</td>
<td>3.07</td>
</tr>
<tr>
<td>S₃ - 30</td>
<td>23.44</td>
<td>3.12</td>
</tr>
<tr>
<td>S₄ - 40</td>
<td>24.94</td>
<td>3.27</td>
</tr>
<tr>
<td>S.Em.±</td>
<td>0.48</td>
<td>0.07</td>
</tr>
<tr>
<td>C.D. at 5 %</td>
<td>1.38</td>
<td>0.20</td>
</tr>
<tr>
<td>C.V. %</td>
<td>7.19</td>
<td>7.84</td>
</tr>
<tr>
<td><strong>Interaction K X S</strong></td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>
Fig. 4.3 Earhead length and girth as influenced by different levels of potassium and sulphur at harvest
and their analysis of variance is given in Appendix II. The data are also graphically illustrated in Fig.4.3.

### 4.2.3.1 Effect of potassium

The perusal of data presented in Table 4.4 indicated that significantly higher earhead girth (3.28 cm) was recorded under treatment $K_4$ (120 kg $K_2O$ ha$^{-1}$) but it was statistically at par with treatment $K_3$ (90 kg $K_2O$ ha$^{-1}$). Significantly the lowest earhead girth (2.84 cm) was observed under treatment $K_1$ (Control).

### 4.2.3.2 Effect of sulphur

The result summarized in Table 4.4 revealed that treatment $S_4$ (40 kg S ha$^{-1}$) produced significantly higher earhead girth (3.27cm) but it remained at par with $S_3$ (30 kg S ha$^{-1}$) and $S_2$ (20 kg S ha$^{-1}$) treatment whereas significantly the lowest earhead girth (2.84 cm) was noted under treatment $S_1$ (Control).

### 4.2.3.3 Interaction effect

The interaction effect between potassium and sulphur failed to manifest any significant effect on earhead girth of summer pearl millet.

### 4.2.4 Test weight

The data pertaining to test weight (g) as influenced by various levels of potassium and sulphur are furnished in Table 4.5 and their analysis of variance is given in Appendix II.
### Table - 4.5: Test weight of pearl millet as influenced by different levels of potassium and sulphur

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Test weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Potassium (kg K₂O ha⁻¹)</strong></td>
<td></td>
</tr>
<tr>
<td>K₁ - 0</td>
<td>8.71</td>
</tr>
<tr>
<td>K₂ - 60</td>
<td>9.23</td>
</tr>
<tr>
<td>K₃ - 90</td>
<td>9.28</td>
</tr>
<tr>
<td>K₄ - 120</td>
<td>9.45</td>
</tr>
<tr>
<td>S.Em.±</td>
<td>0.14</td>
</tr>
<tr>
<td>C.D. at 5%</td>
<td>0.41</td>
</tr>
<tr>
<td><strong>Sulphur (kg S ha⁻¹)</strong></td>
<td></td>
</tr>
<tr>
<td>S₁ - 0</td>
<td>8.71</td>
</tr>
<tr>
<td>S₂ - 20</td>
<td>9.24</td>
</tr>
<tr>
<td>S₃ - 30</td>
<td>9.28</td>
</tr>
<tr>
<td>S₄ - 40</td>
<td>9.44</td>
</tr>
<tr>
<td>S.Em.±</td>
<td>0.14</td>
</tr>
<tr>
<td>C.D. at 5%</td>
<td>0.41</td>
</tr>
<tr>
<td>C.V. %</td>
<td>5.37</td>
</tr>
<tr>
<td><strong>Interaction K X S</strong></td>
<td><strong>NS</strong></td>
</tr>
</tbody>
</table>
4.2.4.1  **Effect of potassium**

A perusal of data presented in Table 4.5 showed that various levels of potassium had significant effect on test weight. Treatment $K_4$ (120 kg K$_2$O ha$^{-1}$) produced significantly higher test weight (9.45 g) as compared to treatment $K_1$ (Control) which recorded significantly the lower test weight (8.71 g).

4.2.4.2  **Effect of sulphur**

An examination of data illustrated in Table 4.5 indicated that treatment $S_4$ (40 kg S ha$^{-1}$) produced significantly higher test weight (9.44 g) than treatment $S_1$ (Control) which produced significantly the lowest test weight (8.71 g).

4.2.4.3  **Interaction effect**

The interaction effect of potassium and sulphur failed to manifest their significant effect on test weight of summer pearl millet.

4.2.5  **Grain yield**

The data regarding grain yield (kg ha$^{-1}$) as influenced by different levels of potassium and sulphur are summarized in Table 4.6 and their analysis of variance is given in Appendix II. The data are also graphically depicted in Fig.4.4.

4.2.5.1  **Effect of potassium**

A perusal of data given in Table 4.6 revealed that grain yield was significantly influenced by various levels of potassium. Significantly higher grain yield (3629 kg ha$^{-1}$) was obtained under treatment $K_4$ (120 kg K$_2$O ha$^{-1}$) but it was statistically at par with treatment $K_3$ (90 kg K$_2$O ha$^{-1}$) while
Table - 4.6: Grain yield, fodder yield and grain : fodder ratio of pearl millet as influenced by different levels of potassium and sulphur

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Grain yield (kg ha(^{-1}))</th>
<th>Fodder yield (kg ha(^{-1}))</th>
<th>Grain : fodder ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Potassium (kg K(_2)O ha(^{-1}))</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K(_1) - 0</td>
<td>2669</td>
<td>5881</td>
<td>0.45</td>
</tr>
<tr>
<td>K(_2) - 60</td>
<td>3129</td>
<td>6528</td>
<td>0.48</td>
</tr>
<tr>
<td>K(_3) - 90</td>
<td>3428</td>
<td>6706</td>
<td>0.52</td>
</tr>
<tr>
<td>K(_4) - 120</td>
<td>3629</td>
<td>6917</td>
<td>0.54</td>
</tr>
<tr>
<td>S.Em.±</td>
<td>103</td>
<td>213</td>
<td>0.02</td>
</tr>
<tr>
<td>C.D. at 5%</td>
<td>298</td>
<td>616</td>
<td>0.05</td>
</tr>
<tr>
<td><strong>Sulphur (kg S ha(^{-1}))</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S(_1) - 0</td>
<td>2696</td>
<td>5941</td>
<td>0.46</td>
</tr>
<tr>
<td>S(_2) - 20</td>
<td>3122</td>
<td>6520</td>
<td>0.48</td>
</tr>
<tr>
<td>S(_3) - 30</td>
<td>3417</td>
<td>6696</td>
<td>0.52</td>
</tr>
<tr>
<td>S(_4) - 40</td>
<td>3619</td>
<td>6875</td>
<td>0.54</td>
</tr>
<tr>
<td>S.Em.±</td>
<td>103</td>
<td>213</td>
<td>0.02</td>
</tr>
<tr>
<td>C.D. at 5%</td>
<td>298</td>
<td>616</td>
<td>0.05</td>
</tr>
<tr>
<td>C.V. %</td>
<td>11.13</td>
<td>11.35</td>
<td>11.82</td>
</tr>
<tr>
<td><strong>Interaction K X S</strong></td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>
Fig. 4.4 Grain yield and fodder yield ratio of pearl millet as influenced by different levels of potassium and sulphur.
treatment K₁ (Control) recorded significantly the lowest grain yield (2669 kg ha⁻¹).

4.2.5.2 Effect of sulphur

An appraisal of results presented in Table 4.6 showed that the effect of sulphur was found to be significant. Application of sulphur @ 40 kg S ha⁻¹ (S₄) recorded significantly higher grain yield (3619 kg ha⁻¹) but it was at par with treatment S₃ (30 kg S ha⁻¹) while significantly the lowest grain yield (2696 kg ha⁻¹) was observed under treatment S₁ (Control).

4.2.5.3 Interaction effect

The interaction effect between potassium and sulphur was not found significant on the grain yield of summer pearl millet.

4.2.6 Fodder yield

The data pertaining to the fodder yield (kg ha⁻¹) of summer pearl millet influenced by varying levels of potassium and sulphur are furnished in Table 4.6 and their analysis of variance is given in Appendix II. The data are also graphically depicted in Fig.4.4.

4.2.6.1 Effect of potassium

The application of potassium produced significant effect on fodder yield (Table 4.6). Significantly higher fodder yield (6917 kg ha⁻¹) recorded under treatment K₄ (120 kg K₂O ha⁻¹) as compared to K₁ (Control) which recorded significantly the lowest fodder yield (5881 kg ha⁻¹).
4.2.6.2 **Effect of sulphur**

A perusal of data presented in Table 4.6 indicated that application of sulphur S₄ (40 kg S ha⁻¹) recorded significantly higher yield of fodder (6875 kg ha⁻¹) as compared to treatment S₁ (Control) which recorded lower fodder yield (5941 kg ha⁻¹) but it remained at par with treatment S₂ (20 kg S ha⁻¹).

4.2.6.3 **Interaction effect**

The interaction effect between potassium and sulphur was not significant on the fodder yield of summer pearl millet.

4.2.7 **Grain: fodder ratio**

The data regarding the effect of potassium and sulphur on grain: fodder ratio of pearl millet are furnished in Table 4.6 and their analysis of variance is given in Appendix II.

4.2.7.1 **Effect of potassium**

The perusal of data presented in Table 4.6 revealed that significantly higher grain: fodder ratio (0.54 %) was recorded under treatment K₄ (120 K₂O kg ha⁻¹) but it was statistically at par with treatment K₃ (90 kg K₂O ha⁻¹). Significantly lower grain: fodder ratio (0.45 %) was observed under treatment K₁ (Control) but it remained at par with treatment K₂ (60 kg K₂O ha⁻¹).

4.2.7.2 **Effect of sulphur**

The result summarized in Table 4.6 revealed that treatment S₄ (40 kg S ha⁻¹) produced significantly higher grain: fodder ratio (0.54 %) but it remained at par with treatment S₃ (30 kg S ha⁻¹) whereas significantly lower grain: fodder ratio (0.46 %)
was noted under treatment $S_1$ (Control) which was at par with
treatment $S_2$ (20 kg S ha$^{-1}$).

4.2.7.3 Interaction effect

The interaction effect between potassium and
sulphur failed to produce significant influence on grain: fodder
ratio of pearl millet.

4.3 QUALITY PARAMETER

4.3.1 Protein content

The data on protein content of pearl millet grains as
influenced by varying levels of potassium and sulphur are
presented in Table 4.7.

4.3.1.1 Effect of potassium

An appraisal of data presented in Table 4.7 revealed
that various levels of potassium did not exert their significant
influence on protein content of pearl millet.

4.3.1.2 Effect of sulphur

An appraisal of data presented in Table 4.7 revealed
that different levels of sulphur did not show their significant
influence on protein content of pearl millet.

4.3.1.3 Interaction effect

Interaction effect of potassium and sulphur in respect
to protein content was observed to be non significant.
Table 4.7: Protein and oil contents in grain of pearl millet as influenced by different levels of potassium and sulphur

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Protein content (%)</th>
<th>Oil content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potassium (kg K₂O ha⁻¹)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>K₁ - 0</td>
<td>8.17</td>
<td>2.87</td>
</tr>
<tr>
<td>K₂ - 60</td>
<td>8.37</td>
<td>3.20</td>
</tr>
<tr>
<td>K₃ - 90</td>
<td>8.43</td>
<td>3.30</td>
</tr>
<tr>
<td>K₄ - 120</td>
<td>8.53</td>
<td>3.54</td>
</tr>
<tr>
<td>S.Em.±</td>
<td>0.15</td>
<td>0.08</td>
</tr>
<tr>
<td>C.D. at 5 %</td>
<td>NS</td>
<td>0.22</td>
</tr>
<tr>
<td>Sulphur (kg S ha⁻¹)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S₁ - 0</td>
<td>8.20</td>
<td>2.87</td>
</tr>
<tr>
<td>S₂ - 20</td>
<td>8.37</td>
<td>3.20</td>
</tr>
<tr>
<td>S₃ - 30</td>
<td>8.44</td>
<td>3.30</td>
</tr>
<tr>
<td>S₄ - 40</td>
<td>8.48</td>
<td>3.54</td>
</tr>
<tr>
<td>S.Em.±</td>
<td>0.15</td>
<td>0.08</td>
</tr>
<tr>
<td>C.D. at 5 %</td>
<td>NS</td>
<td>0.22</td>
</tr>
<tr>
<td>C.V. %</td>
<td>6.02</td>
<td>11.35</td>
</tr>
<tr>
<td>Interaction K X S</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>
Fig. 4.5 Oil contents in grain of pearl millet as influenced by different levels of potassium and sulphur
4.3.2 Oil content

The data on oil content of pearl millet grains as influenced by varying levels of potassium and sulphur are presented in Table 4.7 and their analysis of variance is given in Appendix III. The data are also depicted graphically in Fig. 4.5.

4.3.2.1 Effect of potassium

An appraisal of data presented in Table 4.7 showed that significantly the highest oil content (3.54 %) was recorded when crop was treated with K₄ (120 kg K₂O ha⁻¹) while treatment K₁ (Control) recorded significantly the lowest oil content (2.87 %).

4.3.2.2 Effect of sulphur

The results presented in Table 4.7 indicated that oil content of grains was significantly affected due to varying sulphur levels. Treatment S₄ (40 kg S ha⁻¹) recorded significantly the highest oil content (3.54 %) whereas treatment S₁ (Control) recorded significantly the lowest oil content (2.87 %).

4.3.2.3 Interaction effect

Interaction effect of potassium and sulphur in respect to oil content was observed to be non significant.

4.4.2 Phosphorus content in grains and fodder

Data on the effect of potassium and sulphur on phosphorus content in grains and fodder are given in Table 4.9 and their analysis of variance is given in Appendix IV.
### Table 4.8: Nitrogen content in grain and fodder of pearl millet as influenced by different levels of potassium and sulphur

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Nitrogen content (%)</th>
<th>Grain</th>
<th>Fodder</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Potassium (kg K₂O ha⁻¹)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K₁ - 0</td>
<td>1.31</td>
<td>0.69</td>
<td></td>
</tr>
<tr>
<td>K₂ - 60</td>
<td>1.34</td>
<td>0.72</td>
<td></td>
</tr>
<tr>
<td>K₃ - 90</td>
<td>1.35</td>
<td>0.72</td>
<td></td>
</tr>
<tr>
<td>K₄ - 120</td>
<td>1.37</td>
<td>0.74</td>
<td></td>
</tr>
<tr>
<td>S.Em.±</td>
<td>0.02</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>C.D. at 5 %</td>
<td>NS</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td><strong>Sulphur (kg S ha⁻¹)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S₁ - 0</td>
<td>1.31</td>
<td>0.68</td>
<td></td>
</tr>
<tr>
<td>S₂ - 20</td>
<td>1.34</td>
<td>0.72</td>
<td></td>
</tr>
<tr>
<td>S₃ - 30</td>
<td>1.35</td>
<td>0.73</td>
<td></td>
</tr>
<tr>
<td>S₄ - 40</td>
<td>1.36</td>
<td>0.73</td>
<td></td>
</tr>
<tr>
<td>S.Em.±</td>
<td>0.02</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>C.D. at 5 %</td>
<td>NS</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>C.V. %</td>
<td>6.02</td>
<td>10.53</td>
<td></td>
</tr>
<tr>
<td><strong>Interaction K X S</strong></td>
<td>NS</td>
<td>NS</td>
<td></td>
</tr>
</tbody>
</table>
Table 4.9: Phosphorus content in grain and fodder of pearl millet as influenced by different levels of potassium and sulphur

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Phosphorus content (%)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grain</td>
<td>Fodder</td>
<td></td>
</tr>
<tr>
<td><strong>Potassium (kg K₂O ha⁻¹)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K₁ - 0</td>
<td>0.254</td>
<td>0.072</td>
<td></td>
</tr>
<tr>
<td>K₂ - 60</td>
<td>0.259</td>
<td>0.075</td>
<td></td>
</tr>
<tr>
<td>K₃ - 90</td>
<td>0.263</td>
<td>0.075</td>
<td></td>
</tr>
<tr>
<td>K₄ - 120</td>
<td>0.264</td>
<td>0.077</td>
<td></td>
</tr>
<tr>
<td>S.Em.±</td>
<td>0.005</td>
<td>0.002</td>
<td></td>
</tr>
<tr>
<td>C.D. at 5 %</td>
<td>NS</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td><strong>Sulphur (kg S ha⁻¹)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S₁ - 0</td>
<td>0.250</td>
<td>0.071</td>
<td></td>
</tr>
<tr>
<td>S₂ - 20</td>
<td>0.255</td>
<td>0.075</td>
<td></td>
</tr>
<tr>
<td>S₃ - 30</td>
<td>0.266</td>
<td>0.076</td>
<td></td>
</tr>
<tr>
<td>S₄ - 40</td>
<td>0.269</td>
<td>0.076</td>
<td></td>
</tr>
<tr>
<td>S.Em.±</td>
<td>0.005</td>
<td>0.002</td>
<td></td>
</tr>
<tr>
<td>C.D. at 5 %</td>
<td>NS</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>C.V. %</td>
<td>7.22</td>
<td>10.11</td>
<td></td>
</tr>
<tr>
<td><strong>Interaction K X S</strong></td>
<td>NS</td>
<td>NS</td>
<td></td>
</tr>
</tbody>
</table>
4.4.2.1 Effect of potassium

An examination of data showed in Table 4.9 indicate that varying levels of potassium did not exert their significant influence on phosphorus content in grains and fodder of pearl millet.

4.4.2.2 Effect of sulphur

An appraisal of data delicted in Table 4.9 revealed that different levels of sulphur did not impart their significant influence on phosphorus content in grains and fodder of pearl millet.

4.4.2.3 Interaction effect

Interaction effect of potassium and sulphur in respect to phosphorus content in grains and fodder of pearl millet was found to be non significant.

4.4.3 Potassium content in grains and fodder

Data pertaining to the effect of potassium and sulphur on potassium content in grains and fodder are presented in Table 4.10 and their analysis of variance is given in Appendix IV.

4.4.3.1 Effect of potassium

Different levels of potassium significantly influenced the potassium content in grains and fodder (Table 4.10). Application of potassium K₄ (120 kg K₂O ha⁻¹) produced significantly higher potassium content in grains and fodder (0.327 % and 0.520 %, respectively). However it remained at par with treatment K₃ (90 kg K₂O ha⁻¹). Significantly the lowest
Table 4.10: Potassium content in grain and fodder of pearl millet as influenced by different levels of potassium and sulphur

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Potassium content (%)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grain</td>
<td>Fodder</td>
<td></td>
</tr>
<tr>
<td><strong>Potassium (kg K₂O ha⁻¹)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K₁ - 0</td>
<td>0.297</td>
<td>0.483</td>
<td></td>
</tr>
<tr>
<td>K₂ - 60</td>
<td>0.312</td>
<td>0.498</td>
<td></td>
</tr>
<tr>
<td>K₃ - 90</td>
<td>0.316</td>
<td>0.503</td>
<td></td>
</tr>
<tr>
<td>K₄ - 120</td>
<td>0.327</td>
<td>0.520</td>
<td></td>
</tr>
<tr>
<td>S.Em.±</td>
<td>0.005</td>
<td>0.007</td>
<td></td>
</tr>
<tr>
<td>C.D. at 5 %</td>
<td>0.013</td>
<td>0.021</td>
<td></td>
</tr>
<tr>
<td><strong>Sulphur (kg S ha⁻¹)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S₁ - 0</td>
<td>0.306</td>
<td>0.494</td>
<td></td>
</tr>
<tr>
<td>S₂ - 20</td>
<td>0.310</td>
<td>0.497</td>
<td></td>
</tr>
<tr>
<td>S₃ - 30</td>
<td>0.316</td>
<td>0.505</td>
<td></td>
</tr>
<tr>
<td>S₄ - 40</td>
<td>0.320</td>
<td>0.507</td>
<td></td>
</tr>
<tr>
<td>S.Em.±</td>
<td>0.005</td>
<td>0.007</td>
<td></td>
</tr>
<tr>
<td>C.D. at 5 %</td>
<td>NS</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>C.V. %</td>
<td>5.14</td>
<td>5.04</td>
<td></td>
</tr>
<tr>
<td><strong>Interaction K X S</strong></td>
<td>NS</td>
<td>NS</td>
<td></td>
</tr>
</tbody>
</table>
4.4.3.2 Effect of sulphur

An examination of data showed in Table 4.14 expounded that varying levels of sulphur did not exert their significant influence on potassium content in grains and fodder of pearl millet.

4.4.3.3 Interaction effect

Interaction effect of potassium and sulphur in respect to potassium content in grains and fodder of pearl millet was found to be non significant.

4.4.4 Sulphur content in grains and fodder

Data on sulphur content in grains and fodder as influenced by potassium and sulphur is given in Table 4.11 and their analysis of variance is given in Appendix IV.

4.4.4.1 Effect of potassium

An examination of data given in Table 4.11 expounded that varying levels of potassium could not exert their significant influence on sulphur content in grains and fodder of pearl millet.

4.4.4.2 Effect of sulphur

A perusal of data presented in Table 4.11 showed that varying levels of sulphur significantly influenced the sulphur content in grains and fodder. Treatment $S_4$ (40 kg S ha$^{-1}$) recorded significantly higher sulphur content in grain and fodder (0.274 % and 0.225 %, respectively) which remained at par with treatment $S_3$ (30 kg S ha$^{-1}$). Significantly the lowest
Table 4.11: Sulphur content in grain and fodder of pearl millet as influenced by different levels of potassium and sulphur

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Sulphur content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grain</td>
</tr>
<tr>
<td><strong>Potassium (kg K₂O ha⁻¹)</strong></td>
<td></td>
</tr>
<tr>
<td>K₁ - 0</td>
<td>0.252</td>
</tr>
<tr>
<td>K₂ - 60</td>
<td>0.253</td>
</tr>
<tr>
<td>K₃ - 90</td>
<td>0.263</td>
</tr>
<tr>
<td>K₄ - 120</td>
<td>0.264</td>
</tr>
<tr>
<td>S.Em.±</td>
<td>0.005</td>
</tr>
<tr>
<td>C.D. at 5 %</td>
<td>NS</td>
</tr>
<tr>
<td><strong>Sulphur (kg S ha⁻¹)</strong></td>
<td></td>
</tr>
<tr>
<td>S₁ - 0</td>
<td>0.237</td>
</tr>
<tr>
<td>S₂ - 20</td>
<td>0.255</td>
</tr>
<tr>
<td>S₃ - 30</td>
<td>0.266</td>
</tr>
<tr>
<td>S₄ - 40</td>
<td>0.274</td>
</tr>
<tr>
<td>S.Em.±</td>
<td>0.005</td>
</tr>
<tr>
<td>C.D. at 5 %</td>
<td>0.015</td>
</tr>
<tr>
<td>C.V. %</td>
<td>6.89</td>
</tr>
<tr>
<td>Interaction K X S</td>
<td>NS</td>
</tr>
</tbody>
</table>
potassium content in grains (0.297 %) and fodder (0.483 %) was observed under treatment K₁ (Control). Sulphur content in grains and fodder (0.237 % and 0.188 %, respectively) was observed under the treatment S₁ (Control).

4.4.4.3 Interaction effect

Interaction effect of potassium and sulphur in respect to sulphur content in grains and fodder of pearl millet was found to be non significant.

4.5 NUTRIENT UPTAKE

4.5.1 Nitrogen uptake by grains and fodder

The data pertaining to nitrogen uptake (kg ha⁻¹) by pearl millet grains and fodder as affected by levels of potassium and sulphur are presented in Table 4.12 and their analysis of variance is given in Appendix V. The data are also graphically depicted in Fig.4.6.

4.5.1.1 Effect of potassium

A perusal of data presented in Table 4.12 revealed that there was a significant variation in nitrogen uptake by grains of pearl millet due to various levels of potassium. Application of potassium K₄ (120 kg K₂O ha⁻¹) produced significantly higher nitrogen uptake by grains (49.71 kg ha⁻¹) but it remained at par with treatment K₃ (90 kg K₂O ha⁻¹). Significantly the lowest nitrogen uptake by grains (34.73 kg ha⁻¹) was observed under the treatment K₁ (Control).

The data furnished in Table 4.12 indicated that treatment K₄ (120 kg K₂O ha⁻¹) produced significantly higher nitrogen uptake by fodder (50.93 kg ha⁻¹) as compared to treatment K₁ (Control) while significantly the lowest nitrogen
Table 4.12: Nitrogen uptake by grain and fodder of pearl millet as influenced by different levels of potassium and sulphur

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Nitrogen uptake (kg ha(^{-1}))</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grain</td>
<td>Fodder</td>
<td></td>
</tr>
<tr>
<td><strong>Potassium (kg K(_2)O ha(^{-1}))</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K(_1) - 0</td>
<td>34.73</td>
<td>40.44</td>
<td></td>
</tr>
<tr>
<td>K(_2) - 60</td>
<td>41.98</td>
<td>46.72</td>
<td></td>
</tr>
<tr>
<td>K(_3) - 90</td>
<td>46.30</td>
<td>48.13</td>
<td></td>
</tr>
<tr>
<td>K(_4) - 120</td>
<td>49.71</td>
<td>50.93</td>
<td></td>
</tr>
<tr>
<td>S.Em.±</td>
<td>1.71</td>
<td>2.13</td>
<td></td>
</tr>
<tr>
<td>C.D. at 5 %</td>
<td>4.92</td>
<td>6.14</td>
<td></td>
</tr>
<tr>
<td><strong>Sulphur (kg S ha(^{-1}))</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S(_1) - 0</td>
<td>35.24</td>
<td>40.33</td>
<td></td>
</tr>
<tr>
<td>S(_2) - 20</td>
<td>41.87</td>
<td>47.13</td>
<td></td>
</tr>
<tr>
<td>S(_3) - 30</td>
<td>46.31</td>
<td>48.72</td>
<td></td>
</tr>
<tr>
<td>S(_4) - 40</td>
<td>49.29</td>
<td>50.03</td>
<td></td>
</tr>
<tr>
<td>S.Em.±</td>
<td>1.71</td>
<td>2.13</td>
<td></td>
</tr>
<tr>
<td>C.D. at 5 %</td>
<td>4.92</td>
<td>6.14</td>
<td></td>
</tr>
<tr>
<td>C.V. %</td>
<td>13.68</td>
<td>15.83</td>
<td></td>
</tr>
<tr>
<td><strong>Interaction</strong></td>
<td>K X S</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>
Fig. 4.6 Nitrogen uptake by grain and fodder of pearl millet as influenced by different levels of potassium and sulphur
uptake by fodder (40.44 kg ha\(^{-1}\)) was recorded under treatment K\(_1\) (Control).

4.5.1.2 **Effect of sulphur**

The data presented in Table 4.12 indicated that there was a significant effect of levels of sulphur on nitrogen uptake by grains of pearl millet. Treatment S\(_4\) (40 kg S ha\(^{-1}\)) recorded significantly higher nitrogen uptake by grains (49.29 kg ha\(^{-1}\)) but it was at par with treatment K\(_3\) (90 kg K\(_2\)O ha\(^{-1}\)). The lowest nitrogen uptake by grains (35.24 kg ha\(^{-1}\)) was observed under treatment S\(_1\) (control).

Results given in Table 4.12 indicated that treatment S\(_4\) (40 kg S ha\(^{-1}\)) recorded significantly higher nitrogen uptake by fodder (50.03 kg ha\(^{-1}\)) as compared to treatment S\(_1\) (control). Whereas significantly the lowest nitrogen uptake by fodder (40.33 kg ha\(^{-1}\)) was recorded under treatment S\(_1\) (control).

4.5.1.3 **Interaction effect**

Interaction effect of potassium and sulphur in respect to nitrogen uptake in grains and fodder of pearl millet was found to be non significant.

4.5.2 **Phosphorus uptake by grains and fodder**

The data pertaining to phosphorus uptake (kg ha\(^{-1}\)) by grains and fodder of pearl millet as affected by different levels of potassium and sulphur are presented in Table 4.13 and their analysis of variance is given in Appendix V. The data are also graphically depicted in Fig.4.7.
<table>
<thead>
<tr>
<th>Treatments</th>
<th>Phosphorus uptake (kg ha(^{-1}))</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grain</td>
<td>Fodder</td>
</tr>
<tr>
<td><strong>Potassium (kg K(_2)O ha(^{-1}))</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K(_1) - 0</td>
<td>6.74</td>
<td>4.22</td>
</tr>
<tr>
<td>K(_2) - 60</td>
<td>8.14</td>
<td>4.87</td>
</tr>
<tr>
<td>K(_3) - 90</td>
<td>9.06</td>
<td>5.01</td>
</tr>
<tr>
<td>K(_4) - 120</td>
<td>9.58</td>
<td>5.30</td>
</tr>
<tr>
<td>S.Em.±</td>
<td>0.32</td>
<td>0.22</td>
</tr>
<tr>
<td>C.D. at 5 %</td>
<td>0.93</td>
<td>0.63</td>
</tr>
<tr>
<td><strong>Sulphur (kg S ha(^{-1}))</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S(_1) - 0</td>
<td>6.70</td>
<td>4.21</td>
</tr>
<tr>
<td>S(_2) - 20</td>
<td>7.95</td>
<td>4.91</td>
</tr>
<tr>
<td>S(_3) - 30</td>
<td>9.11</td>
<td>5.07</td>
</tr>
<tr>
<td>S(_4) - 40</td>
<td>9.77</td>
<td>5.21</td>
</tr>
<tr>
<td>S.Em.±</td>
<td>0.32</td>
<td>0.22</td>
</tr>
<tr>
<td>C.D. at 5 %</td>
<td>0.93</td>
<td>0.63</td>
</tr>
<tr>
<td>C.V. %</td>
<td>13.31</td>
<td>15.54</td>
</tr>
<tr>
<td><strong>Interaction K X S</strong></td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>
Fig. 4.7 Phosphorus uptake by grain and fodder of pearl millet as influenced by different levels of potassium and sulphur
4.5.2.1 **Effect of potassium**

The data summarized in Table 4.13 revealed that the different potassium levels also produced significant effect on phosphorus uptake by grains of pearl millet. Significantly higher phosphorus uptake (9.58 kg ha\(^{-1}\)) by grains was recorded under treatment K\(_4\) (120 kg K\(_2\)O ha\(^{-1}\)) which remained at par with treatment K\(_3\) (90 kg K\(_2\)O ha\(^{-1}\)). Significantly the lowest phosphorus uptake (6.74 kg ha\(^{-1}\)) by grains was observed under K\(_1\) (Control).

The data presented in Table 4.13 revealed that treatment K\(_4\) (120 kg K\(_2\)O ha\(^{-1}\)) produced significantly higher phosphorus uptake (5.30 kg ha\(^{-1}\)) by fodder as compared to treatment K\(_1\) (Control) which recorded significantly the lowest phosphorus uptake (4.22 kg ha\(^{-1}\)) by fodder.

4.5.2.2 **Effect of sulphur**

The results revealed that phosphorus uptake was significantly altered due to sulphur application (Table 4.13). Significantly higher uptake (9.77 kg ha\(^{-1}\)) of phosphorus by grains was registered with treatment S\(_4\) (40 kg S ha\(^{-1}\)) which remained at par with treatment S\(_3\) (30 kg S ha\(^{-1}\)) whereas significantly the lowest phosphorus uptake by grains (6.70 kg ha\(^{-1}\)) was observed under treatment S\(_1\) (Control).

The data furnished in Table 4.13 indicated that treatment S\(_4\) (40 kg S ha\(^{-1}\)) produced significantly higher phosphorus uptake (5.21 kg ha\(^{-1}\)) by fodder as compared to treatment S\(_1\) (Control) which recorded significantly the lowest phosphorus uptake by fodder (4.21 kg ha\(^{-1}\)).
4.5.2.3 **Interaction effect**

Interaction effect of potassium and sulphur in respect to phosphorus uptake in grains and fodder of pearl millet was found to be non significant.

4.5.3 **Potassium uptake by grains and fodder**

The data pertaining to uptake (kg ha\(^{-1}\)) of potassium by grains and fodder of pearl millet as affected by various levels of potassium and sulphur are presented in Table 4.14 and their analysis of variance is given in Appendix V. The data are also graphically depicted in Fig.4.8.

4.5.3.1 **Effect of potassium**

Application of potassium to the crop significantly influenced the potassium uptake by grains (Table 4.14). Application of potassium K\(_4\) (120 kg K\(_2\)O ha\(^{-1}\)) produced significantly higher potassium uptake (11.83 kg ha\(^{-1}\)) by grains which was at par with treatment K\(_3\) (90 kg K\(_2\)O ha\(^{-1}\)). Significantly the lowest potassium uptake by grains (7.92 kg ha\(^{-1}\)) was observed under treatment K\(_1\) (Control).

The data presented in Table 4.14 observed that treatment K\(_4\) (120 kg K\(_2\)O ha\(^{-1}\)) produced significantly higher potassium uptake (36.01 kg ha\(^{-1}\)) by fodder as compared to treatment K\(_1\) (Control) which recorded significantly the lowest potassium uptake (28.47 kg ha\(^{-1}\)) by fodder.

4.5.3.2 **Effect of sulphur**

A perusal of data presented in Table 4.14 showed that varying levels of sulphur significantly influenced the potassium uptake by grains. Treatment S\(_4\) (40 kg S ha\(^{-1}\))
Table 4.14: Potassium uptake by grain and fodder of pearl millet as influenced by different levels of potassium and sulphur

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Potassium uptake (kg ha(^{-1}))</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grain</td>
<td>Fodder</td>
</tr>
<tr>
<td>Potassium (kg K(_2)O ha(^{-1}))</td>
<td></td>
<td></td>
</tr>
<tr>
<td>K(_1) - 0</td>
<td>7.92</td>
<td>28.47</td>
</tr>
<tr>
<td>K(_2) - 60</td>
<td>9.80</td>
<td>32.57</td>
</tr>
<tr>
<td>K(_3) - 90</td>
<td>10.88</td>
<td>33.73</td>
</tr>
<tr>
<td>K(_4) - 120</td>
<td>11.83</td>
<td>36.01</td>
</tr>
<tr>
<td>S.Em.±</td>
<td>0.37</td>
<td>1.31</td>
</tr>
<tr>
<td>C.D. at 5 %</td>
<td>1.07</td>
<td>3.78</td>
</tr>
<tr>
<td>Sulphur (kg S ha(^{-1}))</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S(_1) - 0</td>
<td>8.28</td>
<td>29.57</td>
</tr>
<tr>
<td>S(_2) - 20</td>
<td>9.70</td>
<td>32.44</td>
</tr>
<tr>
<td>S(_3) - 30</td>
<td>10.83</td>
<td>33.83</td>
</tr>
<tr>
<td>S(_4) - 40</td>
<td>11.63</td>
<td>34.95</td>
</tr>
<tr>
<td>S.Em.±</td>
<td>0.37</td>
<td>1.31</td>
</tr>
<tr>
<td>C.D. at 5 %</td>
<td>1.07</td>
<td>3.78</td>
</tr>
<tr>
<td>C.V. %</td>
<td>12.68</td>
<td>13.88</td>
</tr>
<tr>
<td>Interaction K X S</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>
Fig. 4.8 Potassium uptake by grain and fodder of pearl millet as influenced by different levels of potassium and sulphur.
recorded significantly higher potassium uptake (11.63 kg ha\(^{-1}\)) by grains but it was at par with treatment S\(_3\) (30 kg S ha\(^{-1}\)). Significantly the lowest potassium uptake (8.28 kg ha\(^{-1}\)) by grains was observed under treatment S\(_1\) (Control).

Results given in Table 4.14 indicated that treatment S\(_4\) (40 kg S ha\(^{-1}\)) recorded significantly higher potassium uptake by fodder (34.95 kg ha\(^{-1}\)) than treatment S\(_1\) (Control) whereas significantly lower potassium uptake by fodder (29.57 kg ha\(^{-1}\)) was recorded under treatment S\(_1\) (Control) which was at par with treatment S\(_2\) (20 kg S ha\(^{-1}\))

### 4.5.3.3 Interaction effect

Interaction effect of potassium and sulphur in respect to potassium uptake in grains and fodder of pearl millet was found to be non significant.

### 4.5.4 Sulphur uptake in grains and fodder

Data on the effect of potassium and sulphur on sulphur uptake in grains and fodder of pearl millet are given in Table 4.15 and their analysis of variance is given in Appendix V. The data are also graphically depicted in Fig.4.9.

#### 4.5.4.1 Effect of potassium

Different levels of potassium significantly influenced the sulphur uptake by grains and fodder (Table 4.15). Application of potassium K\(_4\) (120 kg K\(_2\)O ha\(^{-1}\)) produced significantly higher sulphur uptake (9.58 kg ha\(^{-1}\)) by grains which was at par with treatment K\(_3\) (90 kg K\(_2\)O ha\(^{-1}\)). While significantly the lowest sulphur uptake by grains (6.77 kg ha\(^{-1}\)) was observed under treatment K\(_1\) (Control).
Table - 4.15: Sulphur uptake by grain and fodder of pearl millet as influenced by different levels of potassium and sulphur

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Sulphur uptake (kg ha(^{-1})) by</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grain</td>
</tr>
<tr>
<td>Potassium (kg K(_2)O ha(^{-1}))</td>
<td></td>
</tr>
<tr>
<td>K(_1) - 0</td>
<td>6.77</td>
</tr>
<tr>
<td>K(_2) - 60</td>
<td>7.98</td>
</tr>
<tr>
<td>K(_3) - 90</td>
<td>9.06</td>
</tr>
<tr>
<td>K(_4) - 120</td>
<td>9.58</td>
</tr>
<tr>
<td>S.Em.±</td>
<td>0.31</td>
</tr>
<tr>
<td>C.D. at 5 %</td>
<td>0.90</td>
</tr>
<tr>
<td>Sulphur (kg S ha(^{-1}))</td>
<td></td>
</tr>
<tr>
<td>S(_1) - 0</td>
<td>6.40</td>
</tr>
<tr>
<td>S(_2) - 20</td>
<td>7.95</td>
</tr>
<tr>
<td>S(_3) - 30</td>
<td>9.11</td>
</tr>
<tr>
<td>S(_4) - 40</td>
<td>9.93</td>
</tr>
<tr>
<td>S.Em.±</td>
<td>0.31</td>
</tr>
<tr>
<td>C.D. at 5 %</td>
<td>0.90</td>
</tr>
<tr>
<td>C.V. %</td>
<td>12.98</td>
</tr>
<tr>
<td>Interaction K X S</td>
<td>NS</td>
</tr>
</tbody>
</table>
Fig. 4.9 Sulphur uptake by grain and fodder of pearl millet as influenced by different levels of potassium and sulphur
uptake (12.01 kg ha\(^{-1}\)) by fodder but it was remained at par with K\(_2\) (60 kg K\(_2\)O ha\(^{-1}\)).

### 4.5.4.2 Effect of sulphur

A perusal of data presented in Table 4.15 showed that varying levels of sulphur significantly influenced the sulphur uptake by grains. Treatment S\(_4\) (40 kg S ha\(^{-1}\)) recorded significantly higher sulphur uptake (9.93 kg ha\(^{-1}\)) by grains which was at par with treatment S\(_3\) (30 kg S ha\(^{-1}\)). While significantly the lowest sulphur uptake (6.40 kg ha\(^{-1}\)) by grains was observed under treatment S\(_1\) (Control).

The data furnished in Table 4.15 indicated that treatment S\(_4\) (40 kg S ha\(^{-1}\)) produced significantly higher sulphur uptake of (15.52 kg ha\(^{-1}\)) by fodder but it was at par with treatment S\(_3\) (30 kg S ha\(^{-1}\)) and S\(_2\) (20 kg S ha\(^{-1}\)). Significantly the lowest sulphur uptake by fodder (11.15 kg ha\(^{-1}\)) was recorded under treatment S\(_1\) (Control).

### 4.5.4.3 Interaction effect

Interaction effect of potassium and sulphur in respect to sulphur uptake in grains and fodder of pearl millet was found to be non significant.

### 4.6 NUTRIENT STATUS OF SOIL AFTER HARVEST

#### 4.6.1 Available nitrogen

The data pertaining to available nitrogen (kg ha\(^{-1}\)) in soil after harvest of pearl millet influenced by varying levels of potassium and sulphur are furnished in Table 4.16.
Table 4.16: Availability of nitrogen, phosphorus, potassium and sulphur nutrients in soil after harvest of pearl millet as influenced by different levels of potassium and sulphur

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Nutrient status in soil after harvest (kg ha⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
</tr>
<tr>
<td><strong>Potassium (kg K₂O ha⁻¹)</strong></td>
<td></td>
</tr>
<tr>
<td>K₁ - 0</td>
<td>232.2</td>
</tr>
<tr>
<td>K₂ - 60</td>
<td>238.3</td>
</tr>
<tr>
<td>K₃ - 90</td>
<td>248.6</td>
</tr>
<tr>
<td>K₄ - 120</td>
<td>249.3</td>
</tr>
<tr>
<td>S.Em.±</td>
<td>5.56</td>
</tr>
<tr>
<td>C.D. at 5 %</td>
<td>NS</td>
</tr>
<tr>
<td><strong>Sulphur (kg S ha⁻¹)</strong></td>
<td></td>
</tr>
<tr>
<td>S₁ - 0</td>
<td>234.8</td>
</tr>
<tr>
<td>S₂ - 20</td>
<td>239.1</td>
</tr>
<tr>
<td>S₃ - 30</td>
<td>244.8</td>
</tr>
<tr>
<td>S₄ - 40</td>
<td>249.7</td>
</tr>
<tr>
<td>S.Em.±</td>
<td>5.56</td>
</tr>
<tr>
<td>C.D. at 5 %</td>
<td>NS</td>
</tr>
<tr>
<td>C.V. %</td>
<td>7.96</td>
</tr>
<tr>
<td>Interaction</td>
<td>K X S</td>
</tr>
</tbody>
</table>
4.6.1.1 **Effect of potassium**

An examination of data presented in Table 4.16 indicated that different levels of potassium did not exert their significant influence on available nitrogen status of soil after harvest.

4.6.1.2 **Effect of sulphur**

An assessment of data delicted in Table 4.16 showed that different levels of sulphur did not show their significant influence on available nitrogen status of soil after harvest.

4.6.1.3 **Interaction effect**

Data regarding interaction effect between potassium and sulphur on available nitrogen (kg ha\(^{-1}\)) in soil was not found significant.

4.6.2 **Available phosphorus**

The data on available phosphorus (kg ha\(^{-1}\)) in soil after harvest of pearl millet as influenced by varying levels of potassium and sulphur are presented in Table 4.16.

4.6.2.1 **Effect of potassium**

An examination of data dedicated in Table 4.16 delicted that different levels of potassium did not exert their significant influence on available phosphorus status of soil after harvest.

4.6.2.2 **Effect of sulphur**

An assessment of data delicted in Table 4.16 indicated that different levels of sulphur did not exert their
significant influence on available phosphorus status of soil after harvest.

### 4.6.2.3 Interaction effect

Interaction effect of potassium and sulphur with respect to available phosphorus was observed to be non significant.

### 4.6.3 Available potassium

The data pertaining to the available potassium (kg ha\(^{-1}\)) in soil after harvest of pearl millet influenced by varying levels of potassium and sulphur are furnished in Table 4.16.

#### 4.6.3.1 Effect of potassium

The application of potassium indicated significant effect on available potassium in soil after harvest of pearl millet. Significantly higher available potassium status (234.4 kg ha\(^{-1}\)) was recorded due to an application of potassium @ 120 kg K\(_2\)O ha\(^{-1}\) (K\(_4\)) but it was at par with treatment K\(_3\) (90 kg K\(_2\)O ha\(^{-1}\)) while significantly the lowest available potassium status (195.8 kg ha\(^{-1}\)) was recorded under treatment K\(_1\) (Control).

#### 4.6.3.2 Effect of sulphur

An examination of data show in Table 4.16 indicated that different levels of sulphur did show their significant influence on available potassium status of soil after harvest.

#### 4.6.3.3 Interaction effect

Interaction effect of potassium and sulphur in respect to available potassium in soil was observed to be non significant.
4.6.4 Available sulphur

The data on available sulphur in soil after harvest of pearl millet as influenced by varying levels of potassium and sulphur are presented in Table 4.16.

4.6.4.1. Effect of potassium

An assessment of data presented in Table 4.16 indicated that different levels of potassium did not indicate their significant influence on available sulphur status of soil after harvest.

4.6.4.2. Effect of sulphur

The data given in Table 4.16 revealed that the effect of sulphur was found to be significant. Significantly higher available sulphur in soil after harvest (9.0 Kg ha\(^{-1}\)) was observed when sulphur was applied @ 40 kg S ha\(^{-1}\) (S\(_4\)) which was at par with treatment S\(_3\) (30 kg S ha\(^{-1}\)). Whereas significantly the lowest available sulphur in soil after harvest (7.5 Kg ha\(^{-1}\)) was observed under treatment S\(_1\) (Control).

4.6.4.3 Interaction

The interaction effect of potassium and sulphur levels did not exert their significant influence on available sulphur status of soil after harvest.

4.7 ECONOMICS

Economics play an important role in deciding the adoption of particular treatment by the farmers. Therefore, gross realization, net realization and benefit cost ratio (BCR) are calculated for various levels of potassium and sulphur presented in Table 4.17. The data are also graphically depicted in Fig.4.10.
### Table 4.17: Economics of different treatments

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Gross return (₹ ha⁻¹)</th>
<th>Cost of cultivation (₹ ha⁻¹)</th>
<th>Net return (₹ ha⁻¹)</th>
<th>Benefit cost ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Potassium (kg K₂O ha⁻¹)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K₁ - 0</td>
<td>29628</td>
<td>14888</td>
<td>14740</td>
<td>1.99</td>
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<tr>
<td>K₂ - 60</td>
<td>34552</td>
<td>15876</td>
<td>18676</td>
<td>2.18</td>
</tr>
<tr>
<td>K₃ - 90</td>
<td>37635</td>
<td>16370</td>
<td>21265</td>
<td>2.30</td>
</tr>
<tr>
<td>K₄ - 120</td>
<td>39752</td>
<td>16864</td>
<td>22888</td>
<td>2.36</td>
</tr>
<tr>
<td><strong>Sulphur (kg S ha⁻¹)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S₁ - 0</td>
<td>29932</td>
<td>14888</td>
<td>15044</td>
<td>2.01</td>
</tr>
<tr>
<td>S₂ - 20</td>
<td>34483</td>
<td>15110</td>
<td>19373</td>
<td>2.28</td>
</tr>
<tr>
<td>S₃ - 30</td>
<td>37520</td>
<td>15221</td>
<td>22299</td>
<td>2.46</td>
</tr>
<tr>
<td>S₄ - 40</td>
<td>39631</td>
<td>15332</td>
<td>24299</td>
<td>2.58</td>
</tr>
</tbody>
</table>
V. DISCUSSION

A long discussion of the results obtained from the experiment testing the effect of potassium and micro-nutrients on yield and quality of rice plants. The chapter has been divided into four sections: the first section introduces the methodology, the second section discusses the results, the third section compares the results with previous studies, and the fourth section presents a conclusion based on the findings. The entire chapter has been revised and updated to include the latest research findings.
5.2 **EFFECT ON PLANT POPULATION**

From the data presented in Table 4.1 revealed that initial and final plant population were not influenced significantly due to application of different levels of potassium and sulphur. This indicated that application of potassium and sulphur had no influence on germination and emergence which tended to indicate that plant population was uniform in all the treatments and there was no any adverse effect on pearl millet crop.

5.3 **EFFECT OF POTASSIUM**

5.3.1 **Effect on growth attributes**

Data presented in Table 4.2 indicated that plant height recorded at 30, 60 DAS and at harvest was increased with increase in levels of potassium wherein treatment K₄ (120 kg K₂O ha⁻¹) recorded significantly higher plant height at 30, 60 DAS and at harvest but it remained at par with treatment K₃ (90 kg K₂O ha⁻¹). Thus there is an increase in plant height with potassium application throughout the crop growth span. The probable reason might be positive effect of potassium on growth character due to augment of cell division and cell expansion. The study was in close conformity observed by Sofi et al. (2005), Rajput (2006), Sheta et al. (2010) and Kacha et al. (2011).

Number of total tillers per plant at harvest were also increased with an increase in potassium levels (Table 4.3) wherein an application of potassium @ 120 kg K₂O ha⁻¹ produced significantly more number of total per plant at harvest over control. Potash enhances the development of strong cell walls and therefore stiffer straw which might be resulted into profuse tillering. These results are already in agreement with
A brief discussion of the results obtained from the present investigation entitled “Effect of potassium and sulphur on growth, yield and quality of summer pearl millet [Pennisetum glaucum (L.)]” has been presented in this chapter. It has been attempted to establish “Effect and cause relationship” in light of available evidences and literature. For the sake of convenience, the entire chapter has been divided into following heads.

5.1 EFFECT OF WEATHER ON CROP

5.2 EFFECT ON PLANT POLPULATION

5.3 EFFECT OF POTASSIUM

5.4 EFFECT OF SULPHUR

5.5 INTERACTION EFFECT OF POTASSIUM AND SULPHUR

5.6 ECONOMICS

5.1 EFFECT OF WEATHER ON CROP

The meteorological data recorded in the course of investigation (Table 1) showed that the weather conditions during the period of experiment were normal for satisfactory growth and development of crop. During the whole experimental period, the crop remained free from pest and diseases. The crop stand was also normal and uniform. As the crop was normal during experimentation whatever variations observed can be attributed to the different treatments exercised in the experiment.
5.2

EFFECT ON PLANT POPULATION

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5.3

EFFECT OF POTASSIUM

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Number of total tillers per plant at harvest were also increased with an increase in potassium levels (Table 4.3) wherein an application of potassium @ 120 kg K₂O ha⁻¹ produced significantly more number of total per plant at harvest over control. Potash enhances the development of strong cell walls and therefore stiffer straw which might be resulted into profuse tillering. These results are already in agreement with
those reported by Jain and Poonia (2003), Sofi et al. (2005), More et al. (2004) and Kacha et al. (2011).

5.3.2 Effect on yield attributes and yield

Most of the yield attributes *viz.* number of effective tillers per plant, (Table 4.3), earhead length and girth (Table 4.4), and test weight (Table 4.5) were also improved due to potassium application wherein upper level of potassium (120 kg K₂O ha⁻¹) recorded significantly higher values of yield attributes over control (K₁). The probable reason for increase in test weight due to higher level of potassium might be attributed to the better filling of grains resulting into bold sized seeds and consequently higher test weight. Thus, all the yield attributes were remarkably improved and gave significant response of potassium application. The beneficial effect of potassium in growth and yield attributes were also reported by Singh et al. (2003), More et al. (2004), Heidari and Jamshid (2010) and Kacha et al. (2011).

The grain and fodder yields (Table 4.6) of pearl millet were also increased with an increase in potassium application wherein significantly higher grain yield was recorded with 120 kg K₂O ha⁻¹ (K₄) as compared to control (K₁). The higher grain yield could be due to the cumulative effect of improvement in yield attributes *viz.* number of effective tillers per plant, ear head length and thickness and test weight. Similarly, fodder yield was also significantly increased due to 120 kg K₂O ha⁻¹ as compared to control. The improvement in fodder yield was mainly on account of increase in the growth parameters due to potassium application. These results are also in agreement with findings of Choi et al. (1989), Park et al. (1989), Araujo et al. 2004, More et al. (2004), Yadav et al. (2006), Heidari and Jamshid (2010), Kacha et al. (2011) and Tariq et al. (2011).
5.3.3 Effect on quality parameters, nutrients content and uptake

Appreciable increase in oil per cent in pearl millet grain was noticed with an increase in subsequent level of potassium (Table 4.7). Application of 120 kg K₂O ha⁻¹ (K₄) topped the list by recording remarkably higher per cent oil in grain over no potassium application (K₁). Potassium plays an important role in the synthesis of amino acid which constitutes building block of protein and might have resulted in higher oil contents. The results are in accordance with those reported by Yadav et al. (2006) and Haji et al. (2009) and Brar et al. (2011).

An application of potassium (0 to 120 kg K₂O ha⁻¹) to summer pearl millet crop significantly increased the potassium content in grain and fodder (Table 4.10) as well as nutrients (N, P, K and S) uptake by grain and fodder (Table 4.12 to Table 4.15) over control. Thus, there is an increase in potassium content as well as nutrients (N, P, K and S) uptake by grain and fodder with potassium application up to 120 kg K₂O ha⁻¹ might be due to favorable effects of potassium on growth parameters and yield attributes which ultimately resulted in higher grain and fodder yields (Table 4.5) and consequently more potassium uptake by the crop. The findings are in accordance with those of Meisheri et al. (1995) and Haji et al. (2009).

5.4 EFFECT OF SULPHUR

5.4.1 Effect on growth attributes

An appraisal of data on growth parameters in Table 4.2 revealed that application of sulphur significantly increased plant height at 30, 60 DAS and at harvest. Higher plant height (28.32, 133.31 and 154.89 cm at 30, 60 DAS and at harvest,
respectively) was recorded with an application of 40 kg S ha\(^{-1}\) (S\(_4\)) as compared to no sulphur application (S\(_1\)). The increase in plant height with an increase in sulphur level might be due to the beneficial effect of sulphur on the various metabolic activities and also because of its important role in cell division, photosynthetic process and formation of chlorophyll in the leaf. Therefore an increase in plant height due to application of sulphur was also observed by Sarkar \textit{et al.} (1991), Dadhich and Gupta (2003), Dadhich and Gupta (2005) and Degra \textit{et al.} (2008).

Number of total tillers per plant at harvest was significantly influenced due to sulphur fertilization (Table 4.3). Higher number of tillers per plant was observed under application of 40 kg S ha\(^{-1}\) (S\(_4\)) as compared to no sulphur application (S\(_1\)). These results are in conformity with the results observed by Dadhich and Gupta (2004) and Dadhich and Gupta (2005).

5.4.2 Effect on yield attributes and yield

Fertilizing the crop with sulphur significantly increased the yield attributes of pearl millet crop (Table 4.3, 4.4 and 4.5) over no sulphur application. Application of sulphur at 40 kg ha\(^{-1}\) (S\(_4\)) remarkably increased number of effective tillers per plant (2.73), earhead length (24.94 cm), earhead girth (3.27 cm) and test weight (9.44 g) as compared to S\(_1\) (control). Thus an increase in different yield attributing characters might be due to sulphur application because sulphur is a part of amino acid (Cystine) which helps in chlorophyll formation, photosynthetic process, activation of enzymes and seed formation. Rise in different yield attributing characters like effective tillers per plant, earhead length, earhead girth and test
weight were also recorded by Dadhich and Gupta (2003), Sharma and Gupta (2003), Dadhich and Gupta (2005) and Degra et al. (2008).

Application of sulphur brought significant variation in grain and fodder yields of pearl millet (Table 4.6). The significant response in grain (3619 kg ha\(^{-1}\)) and fodder (6875 kg ha\(^{-1}\)) yields of pearl millet were obtained under application of 40 kg S ha\(^{-1}\) (S\(_4\)) as compared to control (S\(_1\)). The higher yields with sulphur application could be ascribed to accelerated nutrients uptake (Table 4.8 to 4.15) which helped the plants to put optimum growth. As these growth and yield attributes as well as nutrients uptake showed significant increase in grain yield (Table 4.6) with sulphur fertilization. Likewise, fodder yield was also increased significantly due to significant response of plant growth parameters viz., plant height and number of tillers per plant (Table 4.2). Similar results were reported by Jat et al. (2002), Sharma and Manohar (2002), Chejara et al. (2003), Dadhich and Gupta (2003), Sharma and Gupta (2003) and Yadav and Nand (2004).

5.4.3 Effect on quality parameters, nutrients content and uptake

Data presented in Table 4.7 showed that application of sulphur to pearl millet enhanced the oil contents. The highest oil contents in grains of pearl millet were significantly observed with an application of 40 kg S ha\(^{-1}\) (S\(_4\)) as compared to no sulphur application (S\(_1\)). The probable result might be that sulphur plays an important role in synthesis of essential amino acids like Cysteine, Cystine, Methionine and certain vitamins like Biotin, Thiamine, Vitamin B\(_1\) as well as formation of ferrodoxin an iron-containing plant protein that acts as an
electron carrier in the photosynthetic process and chlorophyll which required for the production of oil. Similar results were also obtained by Jat et al. (2002), Jakhar et al. (2003), Sharma et al. (2004), Dadhich and Gupta (2005) and Sheta et al. (2010).

Crop fertilized with 40 kg S ha\(^{-1}\) appreciably increased sulphur content in grains and fodder (Table 4.10) as well as nutrients (N, P, K and S) content and uptake by both grain and fodder (Table 4.12 to Table 4.15). The probable reason for higher uptake of S under higher application of sulphur was that sulphur might have increased its concentration in soil solution which increased the availability and uptake of sulphur by the plants. More over increasing trend of grain and fodder yield as well as sulphur content in grain and fodder were also noticed with sulphur application. The results are in conformity with the work of Jat et al. (2002), Chejara et al. (2003), Dadhich and Gupta (2004) and Sharma et al. (2004).

5.5 INTERACTION EFFECT OF POTASSIUM AND SULPHUR

Data from present investigation as reported in previous chapter revealed that the interaction effect of potassium and sulphur levels was found non-significant for all the parameters.

5.6 ECONOMICS

Data presented in Table 4.17 revealed that maximum net realization of ₹ 22888 ha\(^{-1}\) along with BCR value of 2.36 was recorded under the treatment K\(_6\) (120 kg K\(_2\)O ha\(^{-1}\)) followed by treatment K\(_3\) (90 kg K\(_2\)O ha\(^{-1}\)) with net realization of ₹ 21265 ha\(^{-1}\) and BCR (2.30). On the contrary, treatment K\(_1\) (Control) recorded minimum net realization of ₹ 14740 ha\(^{-1}\) with
minimum BCR value of 1.99. This might be due to higher grain and fodder yields of pearl millet.

The data on economics of different sulphur levels are presented in Table 4.17 wherein treatment S₄ (40 kg S ha⁻¹) found superior by recording the highest value of net realization (₹ 24299 ha⁻¹) with BCR (2.58) followed by treatment S₃ (30 kg S ha⁻¹) with net realization of (₹ 22299 ha⁻¹) and BCR (2.46). The treatment S₁ (Control) showed the lowest value of net realization ₹ 15044 ha⁻¹ and BCR of 2.01. The increase in profit was mainly due to more grain and fodder yields of pearl millet.
SUMMARY & CONCLUSION
A field experiment was conducted at Instructional Farm, Junagadh Agricultural University, Junagadh during summer, 2011 to study the effect of potassium and sulphur on growth, yield and quality of summer pearl millet. This experiment was conducted with four levels each of potassium viz 0, 60, 90 and 120 kg \( \text{K}_2\text{O} \) ha\(^{-1} \) and sulphur viz 0, 20, 30 and 40 kg S ha\(^{-1} \) in factorial randomized design replicated three times.

**6.1 EFFECT OF POTASSIUM**

6.1.1 Various levels of potassium application did not affect initial and final plant population.

6.1.2 Application of potassium @ 120 kg \( \text{K}_2\text{O} \) ha\(^{-1} \) resulted in significantly higher plant height of 28.4 cm, 133.3 cm, and 156.9 cm at 30, 60 DAS and at harvest, respectively. While, significantly the lowest plant height of 24.0 cm, 90.8 cm and 114.4 cm at 30, 60 DAS and at harvest, respectively was recorded under treatment \( \text{K}_1 \) (control).

6.1.3 Application of potassium @ 120 kg \( \text{K}_2\text{O} \) ha\(^{-1} \) produced significantly higher number of total tillers per plant (4.09). While significantly the lowest number of total tillers per plant (3.62) was recorded under treatment \( \text{K}_1 \) (control).

6.1.4 The yield attributing characters viz; numbers of effective tillers per plant, earhead length, earhead girth and test weight were significantly influenced due to varying levels of potassium. Higher number of effective tillers per plant
earhead length (25.03 cm), earhead girth (3.28 cm) and test weight (9.45 g) were obtained under application of potassium @ 120 kg K₂O ha⁻¹. While treatment K₁ (Control) recorded significantly the lowest values of effective tillers per plant, earhead length, earhead girth and test weight.

6.1.5 Grain yield of pearl millet was significantly influenced due to varying levels of potassium wherein significantly higher grain yield of 3629 kg ha⁻¹ was achieved under treatment K₄ (120 kg K₂O ha⁻¹) but it was at par with treatment K₃ (90 kg K₂O ha⁻¹) whereas treatment K₁ (control) recorded significantly the lowest grain yield (2669 kg ha⁻¹).

6.1.6 An application of potassium @ 120 kg K₂O ha⁻¹ gave significantly higher fodder yield of 6917 kg ha⁻¹ only over control (K₁) which recorded significantly the lowest fodder yield (5881 kg ha⁻¹).

6.1.7 Significantly higher grain to fodder ratio of 0.54 was found under the treatment K₄ (120 kg K₂O ha⁻¹) but it was at par with treatment K₃ (90 kg K₂O ha⁻¹) whereas treatment control (K₁) recorded significantly the lowest grain to fodder ratio (0.45).

6.1.8 Both the extreme levels of potassium application (120 kg K₂O ha⁻¹ and Control) produced significantly the highest (3.54 %) and the lowest (2.87 %) oil contents in pearl millet grains, respectively.

6.1.9 An application of potassium @ 120 kg ha⁻¹ significantly improved the content of potassium and uptake of nitrogen, phosphorus, potassium and sulphur by grains
and fodder as compared to \( K_2 \) (60 kg K\(_2\)O ha\(^{-1}\)) and \( K_1 \) (Control) treatments.

6.1.10 Available potassium status in soil after harvest of pearl millet crop found significantly higher under treatment \( K_4 \) (120 kg K\(_2\)O ha\(^{-1}\)) which was at par with treatment \( K_3 \) (90 kg K\(_2\)O ha\(^{-1}\)) whereas significantly the lowest potassium status in the soil after harvest of the crop was recorded under the treatment control (\( K_1 \)).

6.1.11 An application of potassium @ 120 kg ha\(^{-1}\) earned the maximum net realization of ₹ 22888 ha\(^{-1}\) with 2.36 BCR value. However treatment \( K_1 \) (Control) recorded the minimum values of net realization of ₹ 14740 with 1.99 BCR.

6.2 **EFFECT OF SULPHUR**

6.2.1 Various levels of sulphur application did not exert their significant effect on initial and final plant population.

6.2.2 Application of sulphur @ 40 kg S ha\(^{-1}\) gave higher plant height of 28.4 cm, 131.3 cm and 154.9 cm at 30, 60 days after sowing and at harvest, respectively over \( S_2 \) (20 kg S ha\(^{-1}\)) and \( S_1 \) (Control) treatments. While the lowest plant height of 24.0 cm, 92.1 cm and 115.7 cm at 30, 60 DAS and at harvest, respectively was recorded under treatment \( S_1 \) (control).

6.2.3 An application of sulphur @ 40 kg S ha\(^{-1}\) gave significantly higher number of total tillers per plant (4.08) over control which recorded significantly the minimum number of total tillers per plant (3.61).
6.2.4 The yield attributing characters viz; numbers of effective tillers per plant, earhead length, earhead girth and test weight were significantly higher under treatment $S_4$ (40 kg S ha$^{-1}$) as compared to treatment $S_1$ (Control) which produced significantly the lowest values of number of effective tillers per plant, earhead length, earhead girth and test weight.

6.2.5 Significantly higher grain yield of 3619 kg ha$^{-1}$ was achieved under treatment $S_4$ (40 kg S ha$^{-1}$) over $S_2$ (20 kg S ha$^{-1}$) and $S_1$ (Control) treatments. Whereas treatment $S_1$ (control) recorded significantly the lowest grain yield 2696 kg ha$^{-1}$.

6.2.6 An application of sulphur @ 40 kg ha$^{-1}$ gave significantly higher fodder yield of 6875 kg ha$^{-1}$ as compared to treatment $S_1$ (control) which recorded significantly the lowest fodder yield 5941 kg ha$^{-1}$.

6.2.7 Significantly higher grain to fodder ratio 0.54 was found under treatment $S_4$ (40 kg S ha$^{-1}$) which was at par with treatment $S_3$ (40 kg S ha$^{-1}$).

6.2.8 Both the extreme levels of sulphur application (40 kg K$_2$O ha$^{-1}$ and Control) produced significantly the highest (3.54 %) and the lowest (2.87 %) oil contents in pearl millet grains, respectively.

6.2.9 An application of sulphur @ 40 kg ha$^{-1}$ significantly improved the content of sulphur and uptake of nitrogen, phosphorus, potash and sulphur by grains as well as fodder of pearl millet crop.
6.2.10 Available sulphur status in soil after harvest of pearl millet crop was significantly increased with an application of sulphur up to 40 kg S ha\(^{-1}\).

6.2.11 An application of sulphur @ 40 kg ha\(^{-1}\) earned the maximum net realization of ₹ 24299 ha\(^{-1}\) with 2.58 BCR value. While treatment S\(_1\) (Control) recorded the minimum values of net realization ₹ 15044 with 2.01 BCR.

**CONCLUSION**

Based on the one year experimental results, it was concluded that better crop yield and higher net return can be obtained from summer pearl millet (cv. GHB-538) by fertilizing the crop with 120 kg K\(_2\)O ha\(^{-1}\) and 40 kg S ha\(^{-1}\) along with recommended fertilizer dose (120 kg N ha\(^{-1}\) + 60 kg P\(_2\)O\(_5\) ha\(^{-1}\)) in the medium black calcareous soil of South Saurashtra Agro climatic zone of Gujarat.


APENDICICES
**APPENDIX-I**

Analysis of variance for plant population and growth characters

**MEAN SUM OF SQUARE (M.S.S.)**

<table>
<thead>
<tr>
<th>Source of variance</th>
<th>Plant population</th>
<th>Plant height</th>
<th>No. total tiller per plant</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>d.f.</td>
<td>Initial</td>
<td>Final</td>
</tr>
<tr>
<td>Replication</td>
<td>2</td>
<td>23.86</td>
<td>28.98</td>
</tr>
<tr>
<td>Potassium</td>
<td>3</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Sulphur</td>
<td>3</td>
<td>0.12</td>
<td>0.12</td>
</tr>
<tr>
<td>K X S</td>
<td>9</td>
<td>0.13</td>
<td>0.13</td>
</tr>
<tr>
<td>Error</td>
<td>30</td>
<td>10.05</td>
<td>9.43</td>
</tr>
</tbody>
</table>

**Significant at 1 per cent level of probability**
## APPENDIX – II

Analysis at variance for yield attributes and yield

**MEAN SUM OF SQUARE (M.S.S.)**

<table>
<thead>
<tr>
<th>Source of variance</th>
<th>d.f.</th>
<th>No. effective tiller per plant</th>
<th>Earhead Length</th>
<th>Earhead Girth</th>
<th>Test weight</th>
<th>Grain yield</th>
<th>Fodder yield</th>
<th>Grain to fodder ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replication</td>
<td>2</td>
<td>0.011</td>
<td>1</td>
<td>0.011</td>
<td>0.020</td>
<td>66951.063</td>
<td>40752.750</td>
<td>0.001</td>
</tr>
<tr>
<td>Potassium</td>
<td>3</td>
<td>0.393**</td>
<td>39**</td>
<td>0.393**</td>
<td>1.223**</td>
<td>2091736.056**</td>
<td>2400663.965*</td>
<td>0.018**</td>
</tr>
<tr>
<td>Sulphur</td>
<td>3</td>
<td>0.380**</td>
<td>38**</td>
<td>0.380**</td>
<td>1.214**</td>
<td>1928502.778**</td>
<td>1964984.299*</td>
<td>0.016**</td>
</tr>
<tr>
<td>K X S</td>
<td>9</td>
<td>0.057</td>
<td>6</td>
<td>0.057</td>
<td>0.499</td>
<td>132164.870</td>
<td>667337.262</td>
<td>0.000</td>
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<tr>
<td>Error</td>
<td>30</td>
<td>0.058</td>
<td>3</td>
<td>0.058</td>
<td>0.242</td>
<td>127898.485</td>
<td>545897.706</td>
<td>0.003</td>
</tr>
</tbody>
</table>

* Significant at 5 per cent level of probability
** Significant at 1 per cent level of probability
APPENDIX –III

Analysis at variance for quality parameters
MEAN SUM OF SQUARE (M.S.S.)

<table>
<thead>
<tr>
<th>Source of variance</th>
<th>d.f.</th>
<th>Oil content (%)</th>
<th>Protein content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replication</td>
<td>2</td>
<td>0.029</td>
<td>0.458</td>
</tr>
<tr>
<td>Potassium</td>
<td>3</td>
<td>0.935**</td>
<td>0.191</td>
</tr>
<tr>
<td>Sulphur</td>
<td>3</td>
<td>0.926**</td>
<td>0.132</td>
</tr>
<tr>
<td>K X S</td>
<td>9</td>
<td>0.156</td>
<td>0.558</td>
</tr>
<tr>
<td>Error</td>
<td>30</td>
<td>0.072</td>
<td>0.293</td>
</tr>
</tbody>
</table>

** Significant at 1 per cent level of probability
### Analysis of variance for nutrient contents of grain and fodder

**MEAN SUM OF SQUARE (M.S.S.)**

<table>
<thead>
<tr>
<th>Source of variance</th>
<th>d.f.</th>
<th>Nitrogen content</th>
<th>Phosphorus content</th>
<th>Potassium content</th>
<th>Sulphur content</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Grain</td>
<td>Fodder</td>
<td>Grain</td>
<td>Fodder</td>
</tr>
<tr>
<td>Replication</td>
<td>2</td>
<td>0.007</td>
<td>0.006</td>
<td>0.0001</td>
<td>0.0001</td>
</tr>
<tr>
<td>Potassium</td>
<td>3</td>
<td>0.007</td>
<td>0.004</td>
<td>0.0002</td>
<td>0.0001</td>
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<tr>
<td>Sulphur</td>
<td>3</td>
<td>0.005</td>
<td>0.006</td>
<td>0.0010</td>
<td>0.0001</td>
</tr>
<tr>
<td>K X S</td>
<td>9</td>
<td>0.014</td>
<td>0.012</td>
<td>0.0007</td>
<td>0.0001</td>
</tr>
<tr>
<td>Error</td>
<td>30</td>
<td>0.007</td>
<td>0.006</td>
<td>0.0004</td>
<td>0.0001</td>
</tr>
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</table>

* Significant at 5 per cent level of probability
** Significant at 1 per cent level of probability
APPENDIX -V

Analysis of variance for uptake of nutrients by grain and fodder

MEAN SUM OF SQUARE (M.S.S.)

<table>
<thead>
<tr>
<th>Source of variance</th>
<th>d.f.</th>
<th>Nitrogen uptake</th>
<th>Phosphorus uptake</th>
<th>Potassium uptake</th>
<th>Sulphur uptake</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Grain</td>
<td>Fodder</td>
<td>Grain</td>
<td>Fodder</td>
</tr>
<tr>
<td>Replication</td>
<td>2</td>
<td>22.24</td>
<td>33.04</td>
<td>0.36</td>
<td>0.33</td>
</tr>
<tr>
<td>Potassium</td>
<td>3</td>
<td>500.77**</td>
<td>236.24*</td>
<td>18.53**</td>
<td>2.51*</td>
</tr>
<tr>
<td>Sulphur</td>
<td>3</td>
<td>447.31**</td>
<td>223.18*</td>
<td>21.89**</td>
<td>2.36*</td>
</tr>
<tr>
<td>K X S</td>
<td>9</td>
<td>16.39</td>
<td>37.85</td>
<td>0.64</td>
<td>0.39</td>
</tr>
<tr>
<td>Error</td>
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<td>34.89</td>
<td>54.29</td>
<td>1.24</td>
<td>0.57</td>
</tr>
</tbody>
</table>

* Significant at 5 per cent level of probability
** Significant at 1 per cent level of probability
APPENDIX -VI

Analysis of variance for residual availability of potassium and sulphur in soil after harvesting of crop

MEAN SUM OF SQUARE (M.S.S.)

<table>
<thead>
<tr>
<th>Source of variance</th>
<th>d.f.</th>
<th>Available potassium</th>
<th>Available sulphur</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replication</td>
<td>3</td>
<td>932.3774</td>
<td>0.150</td>
</tr>
<tr>
<td>Potassium</td>
<td>2</td>
<td>3290.6226</td>
<td>1.539</td>
</tr>
<tr>
<td>Sulphur</td>
<td>2</td>
<td>683.7584**</td>
<td>4.509**</td>
</tr>
<tr>
<td>K X S</td>
<td>4</td>
<td>595.2929</td>
<td>1.141</td>
</tr>
<tr>
<td>Error</td>
<td>24</td>
<td>374.9632</td>
<td>0.551</td>
</tr>
</tbody>
</table>

* Significant at 5 per cent level of probability
** Significant at 1 per cent level of probability
## Appendix VII

### Cost of cultivation of summer pearl millet and other details of cost incurred

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Particular</th>
<th>Cost (₹ ha⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>Land preparation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Tractor cultivation (2 hrs @ ₹ 140)</td>
<td>280</td>
</tr>
<tr>
<td></td>
<td>2. Harrowing and planking (2.5 hrs @ ₹ 140)</td>
<td>350</td>
</tr>
<tr>
<td>B.</td>
<td>Sowing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Opening of furrow by bullock for fertilizer application (Pair of bullock with labour)</td>
<td>350</td>
</tr>
<tr>
<td></td>
<td>2. Cost of basal fertilizer application (3 labour)</td>
<td>300</td>
</tr>
<tr>
<td></td>
<td>3. Cost of seed @ 4 kg ha⁻¹ (Rs.60/1 kg seed)</td>
<td>240</td>
</tr>
<tr>
<td></td>
<td>4. Sowing (6 labour)</td>
<td>600</td>
</tr>
<tr>
<td>C.</td>
<td>After cares</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Thinning and gap filling (6 labour)</td>
<td>600</td>
</tr>
<tr>
<td></td>
<td>2. Hand weeding, twice (8 labour)</td>
<td>800</td>
</tr>
<tr>
<td></td>
<td>3. Intercultural, twice (2 pairs of bullock with labour)</td>
<td>700</td>
</tr>
<tr>
<td></td>
<td>4. Watching (30 labour)</td>
<td>1500</td>
</tr>
<tr>
<td></td>
<td>5. Cost of irrigation water 300 Rs day⁻¹</td>
<td>2700</td>
</tr>
<tr>
<td>D.</td>
<td>Harvesting and threshing (24 labour)</td>
<td>2400</td>
</tr>
<tr>
<td>E.</td>
<td>Cost of fertilizer</td>
<td>4068</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>14888</td>
</tr>
</tbody>
</table>

- **Pair of bullock** - 350 ₹ day⁻¹
- **Labour charge** - 100 ₹ day⁻¹
- **Urea** - ₹ 5.84 kg⁻¹ (₹ 292/50 kg)
- **SSP** - ₹ 7.20 kg⁻¹ (₹ 360/50 kg)
## APPENDIX -VIII
Cost of variable inputs (as per treatments)

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Number/quantity required ha(^{-1})</th>
<th>Cost ₹ ha(^{-1})</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Potassium (kg K(_2)O ha(^{-1}))</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K(_1) - 0 kg ha(^{-1})</td>
<td>Control</td>
<td></td>
</tr>
<tr>
<td>K(_2) - 60 kg ha(^{-1})</td>
<td>60 kg ha(^{-1})</td>
<td>988</td>
</tr>
<tr>
<td>K(_3) - 90 kg ha(^{-1})</td>
<td>90 kg ha(^{-1})</td>
<td>1482</td>
</tr>
<tr>
<td>K(_4) - 120 kg ha(^{-1})</td>
<td>120 kg ha(^{-1})</td>
<td>1976</td>
</tr>
<tr>
<td><strong>Sulphur (kg S ha(^{-1}))</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S(_1) - 0 kg ha(^{-1})</td>
<td>Control</td>
<td></td>
</tr>
<tr>
<td>S(_2) - 20 kg ha(^{-1})</td>
<td>20 kg ha(^{-1})</td>
<td>222</td>
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<tr>
<td>S(_3) - 30 kg ha(^{-1})</td>
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<td>333</td>
</tr>
<tr>
<td>S(_4) - 40 kg ha(^{-1})</td>
<td>40 kg ha(^{-1})</td>
<td>444</td>
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</table>

Potassium (Muariate of potash) - ₹ 9.88/kg

Sulphur (Gypsum-18 % S) - ₹ 2.00/kg
## APPENDIX- IX

### Cost of cultivation treatments wise

<table>
<thead>
<tr>
<th>No.</th>
<th>Treatments</th>
<th>Common cost (₹ ha⁻¹)</th>
<th>Treatment Cost (₹ ha⁻¹)</th>
<th>Total cost (₹ ha⁻¹)</th>
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<tbody>
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<td>K₁S₁</td>
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<td>222</td>
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<td>15110</td>
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<td>K₁S₃</td>
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<td>333</td>
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<td>15332</td>
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APPENDIX - X  Economics of different treatment combination

<table>
<thead>
<tr>
<th>Yield (kg ha(^{-1}))</th>
<th>Income (₹ ha(^{-1}))</th>
<th>Gross return (₹ ha(^{-1}))</th>
<th>Total cost of cultivation (₹ ha(^{-1}))</th>
<th>Net return (₹ ha(^{-1}))</th>
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</thead>
<tbody>
<tr>
<td>Grain</td>
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<td>Grain</td>
<td>Stover</td>
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<table>
<thead>
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</tr>
<tr>
<td>Fodder</td>
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