POTASSIUM NUTRITION OF SORGHUM (*Sorghum bicolor* (L.) Moench) UNDER RAINFED CONDITIONS

BY

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C E R T I F I C A T E

Miss K. **ANURADHA** has satisfactorily prosecuted the course of research and that the thesis entitled **"POTASSIUM NUTRITION OF SORGHUM [*Sorghum bicolor* (L.) Moench] UNDER RAINFED CONDITIONS"** submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that the thesis or part thereof has not been previously submitted by her for a degree of any University.

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C E R T I F I C A T E

This is to certify that the thesis entitled "POTASSIUM NUTRITION OF SORGHUM [*Sorghum bicolor* (L.) Moench] UNDER RAINFED CONDITIONS" submitted in partial fulfilment of the requirements for the degree of "MASTER OF SCIENCE IN AGRICULTURE" of Andhra Pradesh Agricultural University, Hyderabad, is a record of the bonafide research work carriedout by **Miss K. ANURADHA** under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee.

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

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DECLARATION

I, K. ANURADHA, hereby declare that the thesis entitled "POTASSIUM NUTRITION OF SORGHUM [*Sorghum bicolor* (L.) Moench] UNDER RAINFED CONDITIONS" is the result of original research work done by me. It is further declared that the thesis or any part thereof has not been published earlier in any manner.

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The experiment was conducted in the rainy season 1988 (June-October) with two sorghum cultivars viz., SPV-462 and CSH-5 and four potash levels; 0, 20, 40 and 60 kg ha^{-1}. The objectives of the investigation were to study the response of sorghum cultivars to potash application and to fix optimum dose of potash under rainfed conditions. Data at fortnightly intervals were collected during the crop season. The data on various growth parameters like plant height, number of leaves, leaf area index, dry weight of

plant parts, dry matter partitioning and days taken for 50% flowering showed that potash at 40 kg ha^{-1} was beneficial.

Various biochemical parameters such as N, P and K uptake and chlorophyll content of the leaves were also improved by the added potassium. Application of potassium to sorghum was found to be beneficial for increasing grain yield. Singificant increase in grain yield was recorded with the application of 40 kg K_2O ha^{-1} (5692 kg ha^{-1}) as against 4383 kg ha^{-1} recorded by control treatment, the increase being 30 per cent. This increase in yield was due to the increase in yield contributing parameters like number of primary and secondary rachii per earhead, number of grains $earhead^{-1}$, 1000 grain weight, LAI, CGR, NAR, HI, uptake of N, P and K and improved chlorophyll content.

Out of the two cultivars, cv. SPV-462 was found to be superior over cv. CSH-5 for many of the characters with added potassium while the hybrid cv. CHS-5 was superior over cv. SPV-462 in respect of harvest index. It is evident that the application of 40 kg K_2O ha^{-1} is beneficial under rainfed situations.

LIST OF ABBREVIATIONS

1. CD: Critical difference
2. CGR: Crop Growth Rate
3. CPE: Cumulative Pan Evaporation
4. Cv: Cultivar
5. DAE: Days After Emergence
6. g: Gram
7. ha: Hectare
8. HI: Harvest Index
9. K: Potash
10. kg: Kilogram
11. LAI: Leaf Area Index
12. N: Nitrogen
13. NAR: Net Assimilation Rate
14. NRA: Nitrate Reductase Activity
15. NS: Not significant
16. P: Phosphorus
17. RGR: Relative Growth Rate

INTRODUCTION

CHAPTER I

INTRODUCTION

Through the ages sorghum has been a vital source of food for millions of people. In semiarid tropics (SAT) it is often the principal means of survival. Sorghum grain is used for human food and as feed for animals. Sorghum has a high yield potential, comparable to those of rice, wheat and maize. It is an important staple crop in western and southern parts of India. The production of sorghum has recently increased in India and is expected to increase further as a result of improved management practices, along with the introduction of hybrids. In India sorghum is mainly grown in Andhra Pradesh, Gujarat, Haryana, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan, Tamil Nadu and Uttar Pradesh. In Andhra Pradesh it is cultivated to the extent of 16,15,119 hectares with a production of 8,96,025 tonnes (Agriculture situation in India 1986-87).

Potassium was first recognised as an essential element for plant growth following the work of Englishman Home (1762). Potassium is essential because of its ability to increase crop yields, its ability to improve crop quality and its role in helping the crop plants to combat a variety of climatic and biological stresses.

The basic process of energy metabolism, the conversion of radiation energy into chemical energy is much controlled by the K^+ status of the plant. High rate of K^+ uptake by root cells depresses the osmotic potential in the cells and this induces water uptake. High rate of translocation occurs in the xylem because of the rapid rate at which K^+ is selectively secreted into the root xylem vessels. Inadequate K^+ supply retards the vegetative and reproductive development and filling of the storage tissue with photosynthates.

Yield response to applied potassium tends to increase as the available K^+ status of the soil decreases. The larger responses to K^+ in soils testing low in K^+ than in soils testing high in K^+ were reported in several places for different crops.

Potassium fertilisers markedly increased the yield of grain and dry matter of all crops, but the magnitude of increase was generally higher in legumes than cereals and oil seeds. On the basis of kg yield per kg K_2O added, the potassium responses ranged between 1 and 11 for paddy, 1-3 for irrigated wheat, 1-4 for unirrigated wheat and 1-5 in case of rabi sorghum (Tandon and Sekhon, 1988).

Fortunately, most of the sorghum growing soils in India at present are relatively rich to medium in potassium status. However, since about 70% of potassium is contained in the sorghum fodder, the continued removal of sorghum fodder from fields can be expected to remove substantial quantities of potassium and deplete the soil of it's potassium reserves. Thus K- fertilization investigations will become more and more important (Mahindra Singh and Krantz - 1972).

Large area is under rainfed sorghum. But very limited work was done so far about the response of sorghum cultivars to added potash application and also potash requirements under rainfed conditions.

Hence, an experiment was conducted with the following objectives:

i) To study the responses of sorghum cultivars to potash application under rainfed conditions.

ii) To fix optimum dose of potash for sorghum under rainfed conditions.

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Very limited published work is available on the potassium nutrition of sorghum. The available literature on the subject is reviewed hereunder.

2.1 ROLE OF POTASSIUM IN PLANT METABOLISM

The major functions of potassium in the plants can be summarised as follows: (Beringer 1978, FAO 1984, Mengel and Kirkby, 1987).

1. Activation of a number of enzymes (about 60, involved in photosynthesis, metabolism of carbohydrates and proteins).

2. Assistance in the synthesis and translocation of carbohydrates, protein synthesis, membrane permeability, stomatal regulation and water utilisation.

3. Improved utilization of nitrogen.

4. Improved utilization of sunlight during cool and cloudy periods.

5. Enhanced resistance of plants in many cases to withstand pests, diseases and stresses such as those created by drought, frost, salinity, sodicity etc.

6. Improved crop quality characteristics in a number of crops, in addition to yield increases which may be as important as yield increases.

7. Involved in cell enlargement and in triggering the growth of meristematic cells.

8. Improves the water status of plants and water use efficiency in general.

Since the famous investigations of the Frenchman Theodone de Saussure (1767-1845) it is known, that potassium K^+ is present in all kinds of plant materials. As K^+ is an essential element for vigorous and healthy plant growth, plants have to take up large quantities of K, a highly mobile nutrient, involved in most, if not all biological processes in the plant.

Enzyme Reactions

Potassium activates different groups of enzymes. For crop production the synthates such as starch synthase, phosphorylase, and ADP glucose pyrophosphorylase (Marschner and Doring 1977; Hawker et al., 1979) as well as the enzymes involved in protein synthesis. Inadequate K^+ nutrition results in low molecular weight sugars and aminoacids (Okamokto, 1967; Ratner and Yeliseova, 1968; Nowakowski, 1971) in plant tissues which may be explained in terms of depressed enzyme activity. The K^+ concentrations required for optimum enzyme activation are rather high and amount to about 50 mM.

Water Economy

A high rated K^+ uptake by root cells depress the osmotic potential in the cells, and this induces water uptake. The uptake of water by roots and the ability of the plant to exploit soil water, therefore, depend on the K^+ status of the plant. Water transport into the xylem vessels is also mainly an osmotic process in which K^+ in its function as an osmoticum is important. K^+ has a beneficial effect on water economy thereby it is having particular importance in practical crop production, since K^+ reduces water losses by transpiration (Brag, 1972) so that more organic matter can be produced per unit water consumed. The mechanism of stomatal closure depends entirely on K^+ flux. For this reason plants not adequately supplied with K^+ are impaired in stomatal opening and closing (Terry and Ulrich 1973). Therefore, this capability of specific K^+ uptake not only controls the water uptake by plant roots to a considerable extent, but also has an impact on transpiration.

Energy Metabolism

The fundamental process on which plant growth and yield formation are based is the conversion of solar energy into chemical energy. The exact K^+ functions in photosynthesis are the production of more ATP and NADPH which means that more energy and more reducing coenzymes are available for synthetic processes.

Ben Zioni et al (1971) have suggested that K^+ circulation in the entire plant is of significance for the upward translocation of nitrate. K^+ is involved in metabolic reactions including those of energy (ATP) synthesis, and energy transfer. Metabolic energy is generated by the chloroplasts in the process of photophosphorylation. Light driven electron transport releases protons from the stroma into the inner space of the thylakoid compartment of the chloroplasts (Trebst, 1974). Cations and especially K^+ are moved out into the stroma of the chlorplast in exchange for this inward movement of protons. According to Lauchli and Pfluger (1978), K^+ in a concentration range of about 100 mM seems to be necessary for high efficiency in energy transfer. The promoting effect of K^+ on photosynthetic ATP synthesis and NADPH production has a general impact on various energy-requiring processes in plant metabolism. The effect of K^+ on CO_2 assimilation has been observed by numerous authors (Ilvashonk and Okanenko, 1970; Estes et al. 1973; Terry and Ulrich, 1973b).

Field crops generally absorb potassium faster than other nutrients and build up drymatter during the early growth. K^+ as a major plant nutrient is often absorbed by plants in amounts equal to or greater than nitrogen. So understanding the physiological functions of K^+ in crops is relevant to the production of plant products of high quality. In developing new cultivars or even new crops, knowledge of the physiological role of K^+ in plants will be of great help.

2.2 POTASSIUM NUTRITION ON GROWTH

Sader and Sauza (1982) reported that the potassium had influence over the plant height of sorghum. Considerable decrease in total height of the sorghum plant grown in K^+ deficient medium was foundout by Muramkar and Karadge (1982). A positive correlation between the K^+ uptake by root and transport to shoot, to shoot growth was reported by Pitman (1972). Olksenko (1988) through his experiments found increased leaf area duration by applying 30 kg K_2O ha^{-1} in sweet sorghum. The K^+ status of the plant and its influence on RGR and NAR was noted by Rama Rao (1986a). Hariprakash Rao (1978) and Ogunlela (1988) observed early flowering in sorghum due to application of potassium.

The retardation of shoot growth due to interruption of potassium supply in maize, wheat, millet and barley was mentioned by Stamp and Geisler (1978). In winter barley a tendency towards more intensive growth due to potassium fertilization was reported by Lasztity (1984).

Rama Rao (1986a) conducted experiments in wheat and several other crops and concluded that the potassium status of the plant influences growth mostly through the formation of leaf surface. The beneficial effect of K^+ in increasing the leaf area in wheat was proposed by Forster (1976).

K^+ status of the plant had its influence on RGR and NAR (Oleksenko, 1988). A good correlation was observed by Pitman (1971) between transport of K^+ from root to shoot and RGR in barley.

2.3 POTASSIUM NUTRITION ON DRYMATTER PRODUCTION

A low drymatter production without K^+ application in sorghum and potted millet was reported by Ekpete (1972).

Murumkar and Karadge (1982) found that K^+ deficiency severely affected dry matter production. A logarithmic increase in dry weight of corn shoots with amount of K^+

added to the nutrient solution was observed by Theodoro et al (1970). Gill and Abichandani (1976) observed higher straw yield with the application of 60 kg K_2O ha^{-1}. A 100 per cent increase in stalk weight by applying potassium along with lime to that of not applied plot was reported by Rasolem (1983). Higher straw yield with increased K^+ application was noticed by Ogunlela (1988).

2.4 YIELD AND YIELD COMPONENTS

2.4.1 Yield

Application of 60 kg K_2O ha^{-1} was on par with 120 kg K_2O ha^{-1} and recorded significantly more grain yield of sorghum than no potash with a response of 301-483 kg ha^{-1} (Nagre, 1982).

Shekhewat et al (1972) obtained significant response of jowar to potassium application. Summary of a number of investigations with sorghum hybrids revealed that the crop absorbed on an average 30 kg K_2O per tonne grain produced (Tandon and Kanwar, 1984). Hariprakash Rao (1978) stated that increased levels of fertilizer application (N, P and K) contributed to increase in grain and straw yields of sorghum. Higher level of 120 kg K_2O ha^{-1} was on par with 60 kg K_2O ha^{-1} and recorded significantly higher sorghum grain yield than control (Nagre and Bothkal, 1978). Shekhawat (1972) recorded significantly higher yields with higher level of potassium than control. Mitocha and Conad (1970) recorded decreased yields of grain sorghum with application of potassium on a careville clay loam and gave a slight yield response on the highly calcareous victoria clay. A significant Fe x K interaction on forage yields was encountered on the careville soil. Significant increase in grain yield of sorghum hybrid was recorded with the application of 60 kg K_2O h^{-1} over no potash (Gill and Abichandan, 1976). Fertilizer experiments have shown that application of NP and NPK significantly increased the grain yield of continuous sorghum, though economic increases could be obtained by the application of nitrogen (Faisal, 1971).

Lutrick and Martin (1977) found that the sorghum grain yields were increased with addition of K.

Hiramath (1977) observed that even though the K^+ status of the soil was high, the response of applied potassium was significant in increasing sorghum yields. Ogunlela (1988) reported that highest grain yields were recorded with increased K- application. K^+ is most significant in stabilizing yields. (Potash and phosphate of Canada, 1988). Small applications of K^+ on sandy soil increases the K^+ concentrations in the soil solution appreciably, and may tune result in the substantial yield increases (Mengel & Aksay, 1971). Pradit and Mangkol (1979) reported increased grain yields with increasing rates of NPK. Koch and Mengel (1977) stated that N stored in vegetative plant parts of wheat could be used for grain production of wheat to a greater extent when the plants were well supplied with K^+ than without K^+. In wheat and several other crops, the potassium status of the plant influences the final yield (Rama Rao, 1986a). Well applied potassium yielded significantly higher than control (no potash) in case of maize (Singh and Ghosh, 1984). The higher K^+ supply to the wheat grown in solution culture increased the yield mainly due to an increase in the single grain weight and crude protein content of the grain (Koch and Mengel, 1977).

2.4.2 Yield Components

Application of 60 kg K_2O ha^{-1} recorded highest 1000 grain weight (Gill and Abichandani, 1976). In grain crops the number of filled ears per unit area and number of grains per ear and the weight of each grain can be improved by K^+ nutrition (Potash and Phosphate Institute of Canada, 1988). Size of seeds and kernals can be improved by adequate K^+ application (Potash and Phosphate Institute of Canada 1988). In field experiments on clay soils in England the grain yield of winter wheat was increased as a consequence of K^+ application by improving the single grain weight (Ralph, 1976). Koch and Mengel (1977) observed that the higher K^+ supply to the wheat grown in solution culture promoted grain filling by the provision of carbohydrates but probably had a favourable influence on the translocation of nitrogenous compounds from the vegetative plant parts to the grain.

In rice, Panda (1984) observed that the potash absorbed upto maximum tillering increased both the number of panicles and grain weight whereas K^+ absorbed after panicle initiation had improved grain weight only.

2.5 BIOCHEMICAL PARAMETERS

2.5.1 Chlorophyll

Chlorophyll content in the leaves was singificantly decreased due to K^+ deprivation. The decline in chlorophyll content would undoubtedly contribute to impairment of photosynthetic machinery under the condition of K^+ deprivation in sorghum (Murumkar and Karadge, 1982).

Oleksenko (1988) observed that the application of 60-120 kg P_2O_5, and 30 kg K_2O ha^{-1} in 8 combinations to sweet sorghum increased the chlorophyll content. Stamp and Geisler (1978) reported depressed chlorophyll content when the potassium supply was interrupted in maize, wheat, millet and barley.

2.5.2 Nitrate Reductase Activity

Dale and Neal (1978) reported that wheat seedlings treated with KNO_3 absorbed and accumulated more nitrate and had higher nitrate reduction levels in leaves.

Minotti (1968) had shown that NO_3^- uptake and translocation were impaired in the absence of either K^+ or Ca^{++}. Blevine et al. (1978) showed that in roots of barley seedlings treated with Ca $(NO_3)_2$, NO_3^- accumulation, organic acid accumulation and NRA were much less than in KNO_3 treated seedlings. Shaner and Boyer (1976), by using NO_3^- depletion and cooling of roots and water-stress showed that the decrease in leaf NRA was due to decreased NO_3^- flux to leaves. In wheat seedlings treated with $NaNO_3$, NO_3^- translocation and accumulation were low unless the seedlings had been given a pretreatment with K^+ (Frost 1978).

2.5.3 Protein

In comparison with K^+ sufficient plants, the shoots of K^+ deficient plants exhibited upto 40% increase in protein concentration while the amount of protein per shoot was much reduced in corn (Theodore Hsiao and Tyner, 1970).

The higher K^+ supply to the wheat grown in solution culture increased crude protein content of the grain (Koch and Mengel, 1977).

Plants inadequately supplied with K^+ showed raised contents of soluble amino acids (Helal and Mengel, 1968) and this depressed rate of protein synthesis was possibly by affecting the total N turnover (Koch and Mengel, 1974).

In experiments with young maize plants, it was found that K^+ deficient plants showed increased protein contents (Hsiao et al. 1970). Generally plants suffering from K^+ deficiency show relatively high contents of low molecular constituents such as amino acids and monohexoses. This observation is due to the fact that protein synthesis and starch synthesis require K^+ (Murates & Akazana, 1968).

2.5.4 Carbohydrates

The higher K^+ supply to the wheat grown in solution culture improved grain filling by the provision of carbohydrates (Koch and Mengal, 1977).

2.5.5 Nitrogen

K^+ application enhanced N- concentration in grain sorghum (Ogunlela, 1988). Murumkar and Karadge (1982) proposed that the total N content of K^+ deficient plants was increased by about 1.5 times to that in control plants. Radi et al. (1973) observed accumulation of total nitrogen due to K^+ deficiency. Loetsch (1971) suggested K^+ level could be a factor in the regulation of nitrogen metabolism in plants.

2.5.6 Phosphorus

P content increases considerably in shoots of K deficient sorghum plants. There was 5 fold increase in the activity of acid phoshhatase in K^+ deficient shoots and this clearly indicates the rapid turnover of metabolism of phosphorus containing compounds in K^+ deficient plants (Murumkar and Karadge, 1982). K application decreased P concentration (Ogunlela, 1988).

2.5.7 Potassium

In sorghum 50-60% of the total uptake of potassium was completed before heading (Roy and Wright, 1974). Murumkar and Karadge (1982) stated that K^+ content was considerably lowered in plant parts when plants were subjected to K^+ deficiency. In sorghum the reduction in K^+ content was of the order of about 90% and this was quite sufficient to provoke metabolic disorders in plants.

K^+ along with N increased sorghum seed K^+ content (Krishnaswamy, 1986). Highest K- rate gave highest K^+ concentration in plant parts (Ogunlela, 1988). The highest doses of 120 kg K_2O ha^{-1} enhanced potassium uptake over the other two doses (Singh and Ghosh, 1984). Potassium concentration in plant tissue increased progressively with increasing potassium levels. It steadily raised from 1.77 in control to 2.06% at 120 kg K_2O ha^{-1} in maize (Singh and Ghosh, 1984).

The K^+ uptake occurred rapidly in the early season and a significant loss of potassium from the plant and the earhead was observed during the week before harvest (Ray and Wright, 1974).

In winter barley, K^+ application at 750 kg K_2O ha^{-1} increased the dry matter and resulted in a significant surplus (30-40%) in the uptake from shooting to flowering. But at the beginning and end of the vegetation period, only an increasing trend in uptake could be observed (Lasztity, 1984).

Barankiewicz (1978) noticed the effects of K^+ deficiency in maize where the K^+ concentration in plants was reduced to half.

2.6 POTASSIUM AND DROUGHT

In many parts of the world where crops are grown with little irrigation if any, moisture stress is regular and widespread. Plants high in K^+ require less water to produce a given yield or conversly more yield can be obtained with only a small increase in water supply.

In soils with a good supply of all nutrients including K^+, root growth and proliferation is encouraged. K^+ stimulates degree and extent of root branching. Greater root penetration usually gives plants better access to soil moisture. A major effect of K^+ is to regulate the opening and closing of stomata. Failure of stomata to close quickly subjects the plants to unnecessary water losses through transpiration (Potash and Phosphate Institute of Canada, 1988).

Fischer and Hsiao (1968) reported that potassium plays a spectacular role in stomatal opening and closure. Increase in turgor in the guard cells is associated with stomatal opening resulted from an increase in K^+ concentration in the cells (Humble and Raschke, 1971).

The lower water loss of the plants well supplied with K^+ was due to a reduction rate (Brag, 1972) which not only depends on the osmotic potential of the mesophyll cells, but was also controlled to a large extent by the opening and closing of the stomata. Terry and Ulrich (1973) found that the plants not adequately supplied with K^+ are impaired in stomatal opening and closing. Potassium deficiency caused stomatal closure in maize leaves (Peaslee and Maro, 1966).

A crop well supplied with K^+ produces more organic matter per unit water consumed (Blanchat et al. 1962). The beneficial effect of an optimum K^+ supply on the transpiration co-efficient has been observed by Amberger (1966) for oats and by Linser and Herwing (1968) for flax.

2.7 POTASSIUM AND SOIL

Tandon and Sekhon (1988) mentioned that the added K^+ ion was mostly held in the soil as an exchangeable form. They also reported that the response to applied K^+ was in the order of laterites red red and yellow and mixed red and black soils.

According to Ramamoorthy and Velayatham (1976), the conversion of exchangeable and/or water soluble, K^+ forms into fixed or difficultly soluble forms and vice-versa, was a slow process while the conversion of exchangeable into water soluble is rather fast.

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted in the rainy season 1988 (June-October) at the Student's Farm, College of Agriculture, Rajendranagar, Hyderabad-500030 on a medium deep alfisol (fine, clayey mixed soil).

3.1 SOIL ANALYSIS

The soil analysis results of the experimental site are furnished hereunder.

Mechanical composition

Textural classification

Sand 61.8%

Silt 17.4%

Clay 20.8%

PH 7.5

EC 2.2 m.mhos cm^{-1}

Soil chemical properties with reference to available N, P and K by depth increments were furnished (Table 1).

Nitrogen

Before sowing the experiment, an average of 194 kg N ha^{-1} upto the depth of 10-30 cm and an average of 102.5 kg N ha^{-1} from 30 to 60 cm depth were recorded. After harvesting the crop an average of 191.5, 190.5, 182.5 and 183.0 kg N ha^{-1} were recorded for treatments K_0 (0 kg), K_1 (20 kg), K_2 (40 kg) and K_3 (60 kg) K_2O ha^{-1} respectively. The higher decrease in K_2 treated plots might be due to more uptake of N by plants.

Phosphorus

The phosphorus content in the soil also followed the same trend as that of nitrogen except that the phosphorus content in the soil was more after harvesting which might be due to the basal dose of phosphorus at the time of sowing.

Potassium

The potassium content of the soil after harvest decreased when compared to the potassium status of the soil before sowing. The order of K^+ status was: $K_0 < K_1 < K_2 < K_3$ which clearly shows that the applied K^+ increased the K^+ status of the soil when compared to control after the harvest of the crop.

Table 1 : Soil chemical properties with reference to available N, P and K by depth increments of the experimental plot

Nutrient	Depth (cm)	Befor sowing the experiment	After harvesting the experiment			
			K_0	K_1	K_2	K_3
NITROGEN	0-15	195	203	197	185	189
	15-30	193	180	184	180	177
	30-45	174	153	150	158	143
	45-60	151	129	115	132	121
PHOSPHORUS	0-15	21.2	23.0	24.2	22.7	20.3
	15-30	20.7	22.7	20.8	18.3	17.7
	30-45	18.2	20.3	20.4	19.4	18.3
	45-60	18.0	16.2	19.7	17.2	18.9
POTASSIUM	0-15	380	330	360	363	374
	15-30	286	280	300	297	310
	30-45	280	280	287	284	290
	45-60	299	278	280	283	279

3.2 SEASONAL WEATHER

The meteorological data for the 1989 rainy season (June to October) were presented in Appendix 1 and Fig. 1.

Rainfall - amount and distribution

The total amount of rainfall recorded was 656 mm received on 54 rainy days for the period from mid June to mid October 1988 which was quite high.

Air Temperature

The maximum and minimum temperatures recorded during the crop growth period were fairly uniform.

Relative Humidity

Relative humidity of air recorded at 0716 hours were always higher when compared with the data recorded at 1416 hours.

Open Pan Evaporation

The daily pan evaporation was low from June to the end of September due to high rainfall and less number of sunshine hours. From then onwards it increased due to nill rainfall and more sunshine hours.

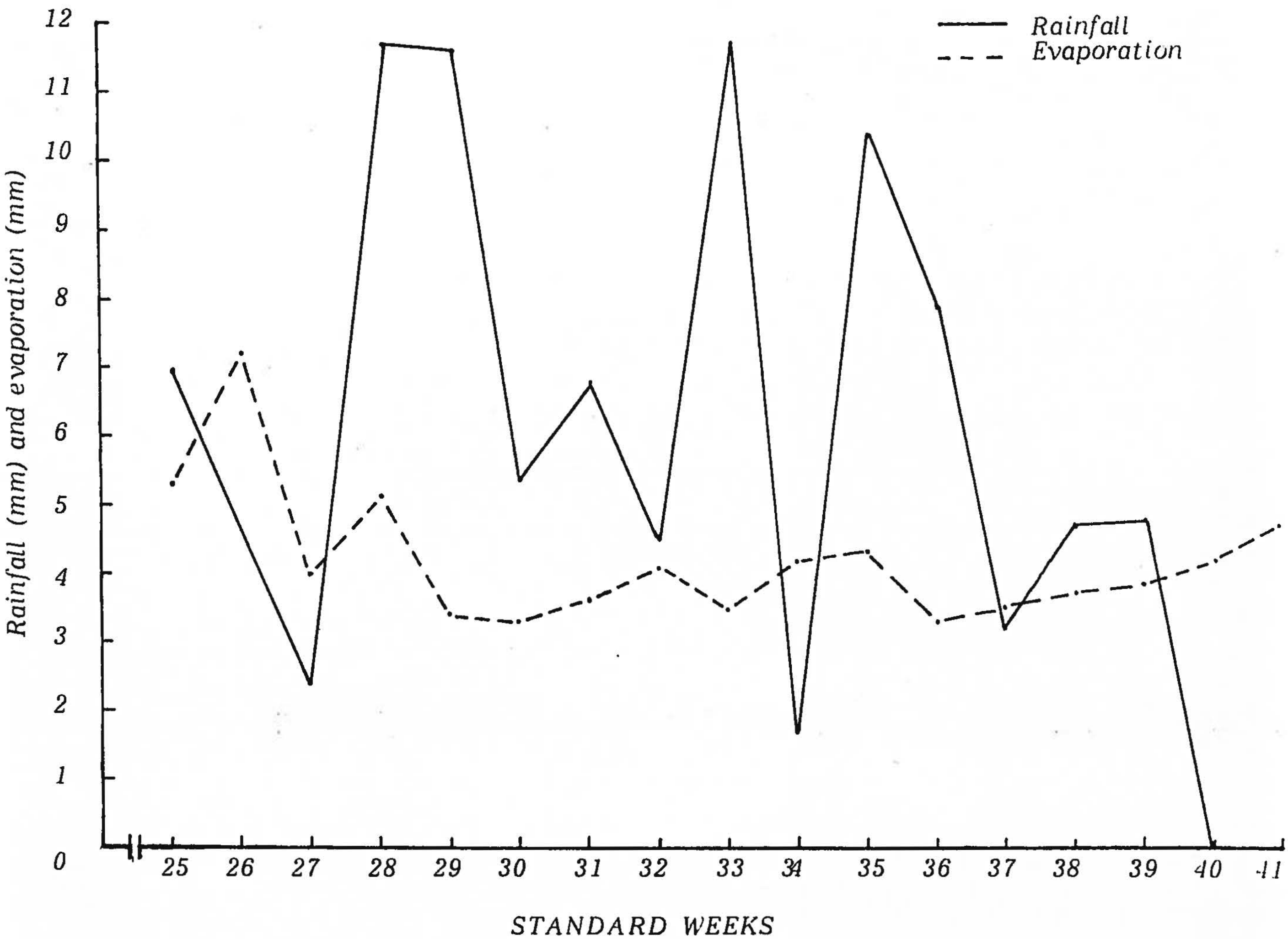

Fig. 1 : Rainfall (mm) and evaporation (mm) during 1988 Kharif season

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3.3 EXPERIMENTAL DETAILS

Treatments

I. Main-plot treatments: 3 moisture treatments

a. Usual rainfall (control)

b. Optimum irrigation

c. 50% less irrigation.

II. Sub-plot treatments: 2 cultivars

a. SPV-462 (Recommended cultivar)

b. CSH-5 (Recommended hybrid)

III. Sub-sub-treatments: 4 levels of potassium 0,20,40 and 60 kg K_2O ha^{-1}.

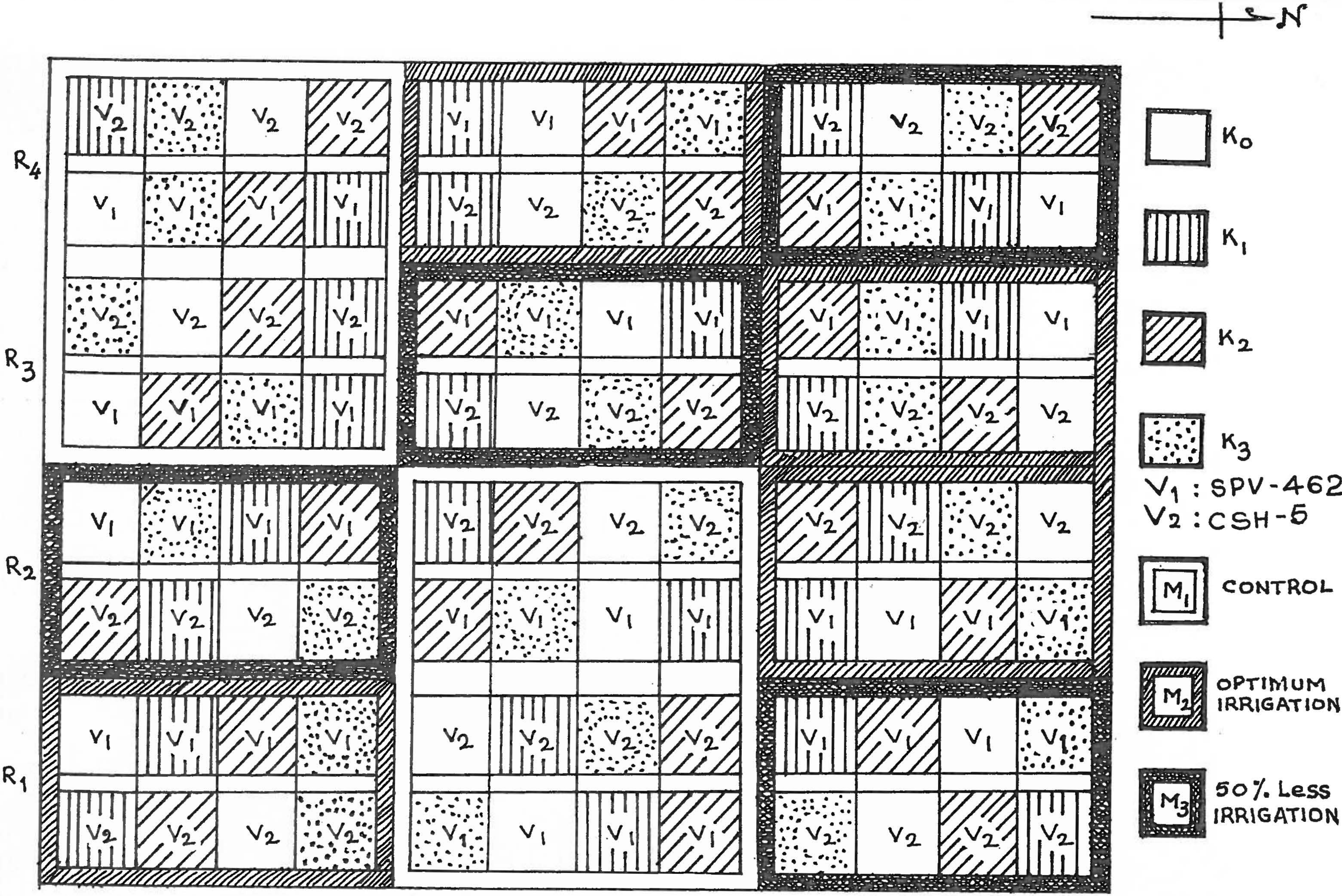
Design: Split-split plot design

Replications: Four

Plot size: 3.0 x 3.6 m.

Spacing: 45 x 15 cm (Lay out plan Fig. 2)

Note: Due to continuous and fairly heavy rains received during 1988 rainy season (656 mm rainfall received on 54 rainy days) the moisture treatments as detailed above could not be imposed. Hence the results pertaining to the response of sorghum cultivars to the potassium application during 1988 rainy season are discussed by analysing the data as Factorial Randomised Block Design.



K_0 = 0 kg K_2O ha^{-1} ; K_1 = 20 kg K_2O ha^{-1} ; 40 kg K_2O ha^{-1}; 60 kg K_2O ha^{-1}.

Fig. 2 FIELD LAYOUT PLAN.

The field was ploughed twice with a tractor and harrowed. Wooden plank was used to break the clods. Dried weeds were removed and the land was levelled.

3.4 APPLICATION OF FERTILISERS

N - 80 kg ha^{-1} (Urea)

P_2O_5- 40 kg ha^{-1} (Single super phosphate)

K_2O - 0, 20, 40, 60 kg ha^{-1} (Muriate of potash) Applied as per the treatments.

Note: 50% of the N and K_2O were applied as basal and remaining 50% was top dressed at knee high stage of crop.

3.5 SOWING

Seed treatment

The seed was treated with fungicide CAPTAF (2 g kg^{-1}) against soil and seed borne diseases).

The seed was sown in lines by dibbling 2 seeds per hill. A week after emergence, the crop was thinned to a single plant per hill.

3.6 PLANT PROTECTION MEASURES

To protect crop from shoot fly attack, Endosulfan was sprayed 2 times at 10 days after emergence and 20 days after emergence (DAE). Furadon granules were applied in plant whorls against stem borer. Endosulfan was once again sprayed on 60 DAE. There was no incidence of any insect throughout the crop growth period. After panicle initiation, captan was sprayed to protect the grain from smut.

3.7 WEEDING AND INTERCULTURAL OPERATIONS

The first weeding was done at 10 DAE with hand hoes and subsequent intercultural operations were done as per the requirements.

3.8 IRRIGATION

Immediately after sowing life saving irrigation was given. Later on the crop was not irrigated due to continuous and fairly good amount of rainfall received during the crop season.

3.9 HARVESTING AND THRESHING

Harvesting was done from each net plot separately when the crop attained physiological maturity i.e. when a black layer at the hyla region of the seed developed. The earheads were threshed, cleaned and labelled separately. The seed was further sun dried till a constant weight was obtained. Similarly the weight of straw from each plot was also recorded after drying in sun to constant weight.

3.10 OBSERVATIONS RECORDED

Plant samples were collected at fortnightly intervals until harvest and several physiological observations were made to understand the role of K^+ nutrition on crop productivity.

A. <u>Morpho-physiological parameters</u>

1. Plant height
2. Number of leaves
3. Leaf area
4. Days taken for 50% flowering
5. Leaf firing
6. Dry wt. of stem, leaf, reproductive parts, total dry matter production and dry matter partitioning
7. Growth analysis

B. <u>Yield and yield components</u>

1. No. of primary and secondary rachii.
2. No. of grains/panicle
3. 1000 grain wt.
4. Yield
5. H.I.

C. <u>Biolchemical studies</u>

1. Epicuticular wax
2. Chlorophyll

3. Nitrate reductase
4. Grain protein
5. NPK content of plant parts (stem, leaf, earhead) and NPK uptake.

The leaf area was measured with LI-3100 area meter (LI - COR Ltd, Lincolin, Nebrask USA). The dry weights of leaves, pods and seeds were recorded after oven drying them at 80°C for 48 hours.

3.11 DAYS TAKEN FOR 50% FLOWERING

The panicle initiation and booting were carefully observed in the plots. Four rows of the middle of the plot were selected for recording 50 per cent flowering. When 50 per cent of the plants in the plot emerged their panicle from boots that was taken as the stage of 50 per cent flowering.

3.12 GROWTH ANALYSIS

The growth analysis was done with five plants in a row in each replication using the following formulae given by Watson (1952), Radford (1967) and Sestak (1971).

3.12.1 <u>Crop growth rate</u> (CGR -g m^{-2} day^{-1})

$$CGR = \frac{dw}{dt} \times \frac{1}{P}$$

where dw = difference in dry weight per land area dt = difference in time

P = land area

3.12.2 Relative Growth Rate (RGR - g g^{-1} day^{-1})

$$RGR = \frac{InW_2 - InW_1}{t_2 - t_1}$$

where: W_1 and W_2 are the dry weights at times t_1 & t_2 respectively.

3.12.3 Net assimilation rate (NAR-g dm^{-2} day^{-1})

$$NAR = \frac{W_2 - W_1}{t_2 - t_1} \times \frac{In\ A_2 - In\ A_1}{A_2 - A_1}$$

where W_1 and W_2 are plant dry weights; A_1 & A_2 are leaf areas at times t_1 and t_2 respectively.

3.12.4 Leaf Area Index (LAI)

$$LAI = \frac{\text{Leaf area}}{\text{Unit ground area}}$$

3.12.5 Harvest Index (H.I.)

$$\frac{\text{Seed yield per ha}}{\text{Total biomass per ha}} \times 100$$

3.12.6 Grain yield

Kg/ha.

3.13 BIO-CHEMICAL PARAMETERS

3.13.1 Chlorophyll Content

The procedure developed by Witham et al (1971) was followed. One gram (fresh weight) of leaf material representing all the foliates was placed in a clean mortar to which 30 ml of 80 percent (V/v) acetone and a pinch of $CaCo_3$ were added. Further the tissue was made to a fine pulp and the contents were transforred to a 100 ml volumetric flask through a funnel having whatman No.1 filter paper. After filtering, the left over pulp was again transferred to a mortar and grinding was repeated till the entire chlorophyll was extracted from the leaf material. Every time care was taken to rinse the mortar and walls of the funnel to ensure that all the chlorophyll was collected. The final volume of the filtrate was made upto 100 ml with 80% acetone. The optical density of chlorophyll extract was read in spectronic 20 set at 652 nm using 80% acetone solvent as blank. Then the amount of chlorophyll present in the extract on the basis of leaf tissue was calculated using the following formula:

mg total chlorophyll g^{-1} fresh tissue

$$= \frac{(D652) \times 1000}{34.5} \times \frac{V}{1000 \times W}$$

where D= optical density at 652 nm

V= Final volume of the 80 percent acetone chlorophyll extract

W= Fresh weight in grams of the tissue

3.13.2 Epicuticular Wax

The first leaf below flag leaf was sampled for wax content. The entries were sampled after the start of grain filling when the epicuticular wax was maximum. The epicuticular wax was extracted from 10 leaf discs by vigorous stirring in 20 ml chloroform for 15 seconds. These discs were cut from the middle of the leaf blade avoiding the midrib. Wax content was measured according to the method (Ebercon et al 1977) after chloroform was evaporated at room temperature.

3.13.3 Nitrate Reductase Activity (NRA)

Nitrate reductase activity was determined by adopting the method of Klepper et al. (1971), using the assay mixture 0.908 g $KH_2 PO_4$ (15 ml from total of 100 ml) + 0.947 g K_2HPO_4 (85 ml from total of 100 ml) and to this KNO_3 is added to give 0.2 M $N\bar{o}_3$.

Leaf discs (0.5 g) were taken into a vial containing 5 ml of assay mixture and the vials were subjected to 0.1 atmospheric pressure for 30 seconds for infiltration in a vaccum chamber. It is then incubated under dark conditions in a water bath at 33°C for one hour. Immediately 3 ml of aliquot was taken into a test tube from the sample and one ml distilled water. One ml of 1 per cent sulfonilamide in 1.5 N Hcl and one ml of 0.02 per cent N-1 Naphthyl ethylone diamine dihydro chloride were added. Colour was allowed to develop for 20 minutes. The optical density of final aliquot was measured at 540 nm using Spectrophotometer. NRA was calculated with standard curve and the results were expressed in terms of u moles of $N\bar{o}_2$ formed hr^{-1} g^{-1} leaf material.

3.13.4 Protein content

Protein percentage was calculated as follows:

Protein percentage = N percentage in seed at harvest x 6.25

3.14 NUTRIENT UPTAKE

3.14.1 Estimation of nitrogen

The per cent N in stem, leaf and grain was estimated at the time of harvest. The Nitrogen was estimated following the Macrojeldhal method (Yoshida et al., 1976).

One gram of the material was digested after adding 10 g of potassium sulphate, 0.3 to 0.5 g of $CusO_4$, 5nn H_{20} and 30 ml of conc. H_2So_4. The digested material was distilled by adding 70 ml of 40% Na OH. Ammonia was collected in boric acid and titrated against H_2So_4. Based on the nitrogen per cent and dry matter production, the nitrogen uptake was calculated.

3.14.2 Potassium

The potassium as determined in triacid extract using Flame Photometer (Jackson, 1967). Based on the per cent of potassium and dry matter production, the uptake of potassium was calculated.

3.14.3 Phosphorus

This was determined by Jackson (1967) method and expressed in kg ha^{-1}. Based on the phosphorus per cent and dry matter production, the uptake of phosphorus was calculated.

3.15 STATISTICAL ANALYSIS

The data collected on growth, development, yield and yield components of the experimental crop were sorted out, tabulated and processed statistically to draw conclusions of significance. Statistical analysis of the data with factorial randomized block design was done by using a micro computer i.e. DCM-spectra-31 : KOS 60. The variation in treatment means was tested by employing CD at 5 per cent probabilities.

RESULTS

CHAPTER IV

RESULTS

4.1 MORPHO-PHYSIOLOGICAL PARAMETERS

4.1.1 Plant Height

The data on plant height (cm) (Table 2 and Fig.3) revealed that there was significant difference between the cultivars, except at 15 days after emergence (DAE). Both the cultivars recorded maximum height at 75 DAE. The same height was maintained upto 90 DAE. Cv. SPV-462 was found superior to cv. CSH-5 and recorded 23.5 per cent more height than cv. CSH-5.

Among potash levels, 40 (K_2) kg K_2O ha^{-1} was found to be significantly superior over 0 (K_0) and 20 (K_1) kg K_2O ha^{-1}. As compared to control, 20 (K_1), 40 (K_2) and 60 (K_3) kg K_2O ha^{-1} were significantly superior. The increase in height was 7.8, 13.05 and 10.58 per cent more for K_1, K_2 and K_3 respectively over control (K_0) at 75 DAE. Increase in the height was in the order of $K_2 > K_3 > K_1 > K_0$.

Interaction between cultivars and potash levels was also significant. Cv. SPV-462 at 40 kg K_2O ha^{-1} recroded maximum plant height. Cv. CSH-5 at 40 kg K_2O ha^{-1} recorded more plant height over other potash levels.

Table 2: Plant height (cm plant^{-1}) of sorghum cultivars as influenced by potash levels during 1988 rainy season

Treatments	DAYS AFTER EMERGENCE					
	15	30	45	60	75	90
<u>Cultivar means</u>						
SPV-462 (C_1)	11.26	38.06	52.81	195.9	207.3	207.3
CSH - 5 (C_2)	11.42	34.81	47.81	166.6	167.8	167.8
C.D. (5%)	NS	2.25	1.96	5.8	6.7	6.7
<u>Potash levels</u> (kg K_2O ha^{-1})						
0 (K_0)	10.07	32.00	41.00	167.9	173.9	173.9
20 (K_1)	10.95	34.75	47.00	178.5	187.4	187.4
40 (K_2)	12.46	40.13	56.50	192.0	196.6	196.6
60 (K_3)	11.88	38.88	56.75	186.8	192.3	192.3
C.D.(5%)	0.77	3.19	2.78	8.1	9.4	9.4
<u>Treatment means</u>						
$C_1 \times K_0$	9.64	33.50	42.50	175.3	184.9	184.9
$C_1 \times K_1$	10.96	35.75	48.75	191.8	208.5	208.5
$C_1 \times K_2$	12.46	42.00	60.25	212.1	221.3	221.3
$C_1 \times K_3$	12.00	41.00	59.75	204.6	214.6	214.6
$C_2 \times K_0$	10.50	30.50	39.50	160.5	163.0	163.0
$C_2 \times K_1$	10.94	33.75	45.25	165.3	166.3	166.3
$C_2 \times K_2$	12.46	38.25	52.75	171.9	172.0	172.0
$C_2 \times K_3$	11.76	36.75	53.75	168.9	169.9	169.9
Cultivar x Potash levels C.D. (5%)	1.09	4.51	3.93	11.5	13.3	13.3

N.S.: Not significant

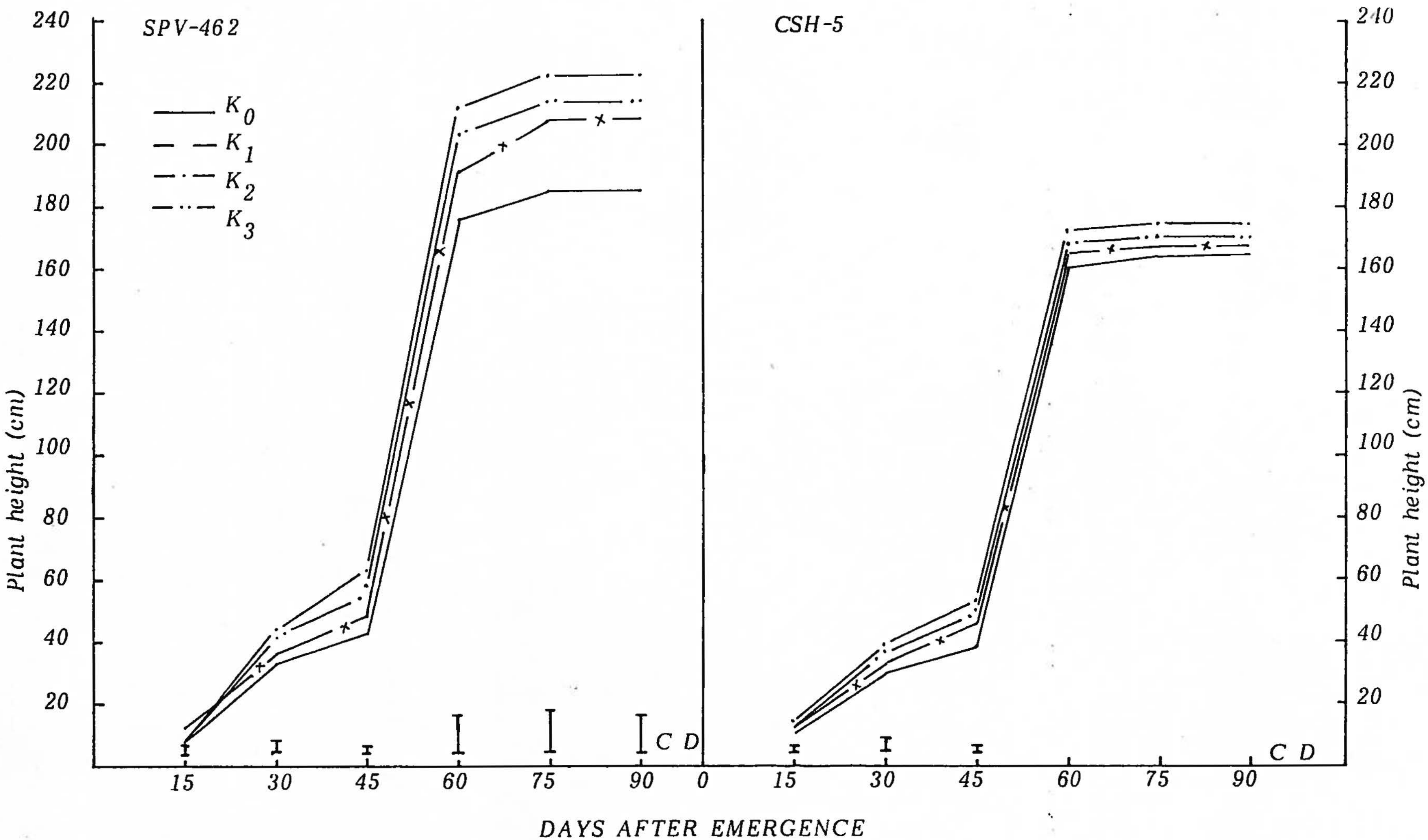


Fig. 3 : Plant height (cm) as influenced by potash levels in sorghum

4.1.2 Number of Leaves $Plant^{-1}$

The data on the number of leaves $plant^{-1}$ recorded for sorghum cultivars (Table 3) showed that the cv. SPV-462 recorded maximum number of leaves on 60 DAE and cv. CSH-5 on 45 DAE. Cv. SPV-462 produced more number of leaves than cv. CSH-5.

Potash levels differed significantly except at 60 DAE. Maximum number of leaves were recorded on 45 DAE. Potash levels at 40 (K_2) and 60 (K_3) kg ha^{-1} were on par but significantly superior over 0 (K_0) and 20 (K_1) kg ha^{-1}.

The interaction between cultivars and potash levels was also significant. Cv. SPV-462 at 40 kg K_2O ha^{-1} recorded maximum number of leaves. In respect of cv. CSH-5, 40 kg K_2O ha^{-1} recorded more number of leaves per plant than other potash levels.

4.1.3 Leaf Firing $Plant^{-1}$

The data recorded (Table 4) on leaf firing $plant^{-1}$ showed no significant difference among cultivars.

Among potash levels, 40 kg K_2O ha^{-1} was found to be superior to other levels. Less number of leaves got fired at potash level 40 kg K_2O ha^{-1}.

Table 3: Number of leaves per plant of sorghum cultivars as influenced by potash levels during 1988 rainy season

Treatments	DAYS AFTER EMERGENCE				
	15	30	45	60	75
Cultivar means					
SPV-462 (C_1)	5.31	6.88	9.38	9.84	5.22
CSH - 5 (C_2)	5.34	7.50	8.72	8.22	5.53
C.D. (5%)	NS	0.39	0.34	0.41	0.28
Potash levels (kg K_2O ha^{-1})					
0 (K_0)	4.88	6.44	8.25	8.88	5.19
20 (K_1)	5.31	6.94	8.81	9.00	5.44
40 (K_2)	5.75	7.88	9.75	9.31	5.63
60 (K_3)	5.38	7.50	9.38	8.94	5.25
C.D.(5%)	0.44	0.55	0.48	NS	0.39
Treatment means					
$C_1 \times K_0$	4.63	6.38	8.63	9.75	4.88
$C_1 \times K_1$	5.25	6.50	9.13	9.75	5.25
$C_1 \times K_2$	5.88	7.50	10.13	10.13	5.50
$C_1 \times K_3$	5.50	7.13	9.63	9.75	5.25
$C_2 \times K_0$	5.13	6.50	7.88	8.00	5.50
$C_2 \times K_1$	5.38	7.38	8.50	8.25	5.63
$C_2 \times K_2$	5.63	8.25	9.38	8.50	5.75
$C_2 \times K_3$	5.25	7.88	9.13	8.13	5.25
Cultivar x Potash levels C.D. (5%)	0.62	0.78	0.68	0.82	0.55

N.S.: Not significant

Table 4: Days for 50% flowering and Leaf firing of sorghum cultivars as influenced by potash levels during 1988 rainy season

Treatments	Days for 50% flowering	Leaf firing
Cultivar means		
SPV-462 (C_1)	67.1	6.63
CSH - 5 (C_2)	67.4	6.72
C.D. (5%)	NS	NS
Potash levels (kg K_2O ha^{-1})		
0 (K_0)	68.5	7.31
20 (K_1)	67.6	6.88
40 (K_2)	66.6	6.06
60 (K_3)	66.5	6.44
C.D.(5%)	0.9	0.45
Treatment means		
$C_1 \times K_0$	68.0	7.13
$C_1 \times K_1$	67.3	6.75
$C_1 \times K_2$	66.8	6.00
$C_1 \times K_3$	66.5	6.63
$C_2 \times K_0$	69.0	7.50
$C_2 \times K_1$	68.0	7.00
$C_2 \times K_2$	66.3	6.13
$C_2 \times K_3$	66.5	6.25
Cultivar x Potash levels		
C.D. (5%)	1.3	0.64

N.S.: Not significant

Interaction between cultivars and potash levels was also significant. Cv. SPV-462 at 40 kg K_2O ha^{-1} was found to be superior. Cv. CSH-5 at the same potash level recorded less leaf firing over other potash levels.

4.1.4 Days Taken for 50 Per Cent Flowering

Days taken for 50 per cent flowering (Table 4) were not significant among the two cultivars.

Days taken for 50 per cent flowering differed significantly among potash levels. Potash at 40 (K_2) and 60 (K_3) kg ha^{-1} resulted in early flowering (50 per cent) than other levels.

Interaction between cultivars and potash levels was also significant. Both the cultivars SPV-462 and CSH-5 taken less number of days for 50 per cent flowering at 40 and 60 kg K_2O ha^{-1}.

4.1.5 Dry Weight of Leaves

The differences in dry weight of leaves (g m^{-2}) between the two cultivars (Table 5) were significant except on 45 and 90 DAE. Cv. SPV-462 produced more leaf dry weight than cv. CSH-5.

Both the cultivars recorded increase in dry weight upto 60 DAE. Later due to leaf senescence, it declined.

Table 5: Dry weight of leaves (g m^{-2}) of sorghum cultivars as influenced by potash levels during 1988 rainy season

Treatments	DAYS AFTER EMERGENCE 15	30	45	60	75	90
Cultivar means						
SPV-462 (C_1)	7.22	69.96	96.64	186.09	142.97	105.0
CSH - 5 (C_2)	9.16	60.79	92.97	163.59	128.44	99.38
C.D. (5%)	0.73	5.16	NS	8.3	7.82	NS
Potash levels (kg K_2O ha^{-1})						
0 (K_0)	6.58	53.62	58.99	120.94	103.13	82.50
20 (K_1)	7.43	63.11	79.44	156.56	127.50	94.69
40 (K_2)	9.63	75.23	125.23	216.58	167.81	125.64
60 (K_3)	9.12	69.55	115.36	205.31	144.38	105.94
C.D.(5%)	1.03	7.29	7.19	11.77	11.06	9.47
Treatment means						
$C_1 \times K_0$	6.64	54.48	60.28	123.75	110.63	84.38
$C_1 \times K_1$	7.14	69.76	80.91	157.50	136.87	93.75
$C_1 \times K_2$	7.60	80.91	126.97	241.88	176.25	131.25
$C_1 \times K_3$	7.50	74.70	118.40	221.25	148.13	110.63
$C_2 \times K_0$	6.51	52.75	57.71	118.13	95.63	80.63
$C_2 \times K_1$	7.72	56.44	77.98	155.63	118.13	95.63
$C_2 \times K_2$	11.66	69.56	123.88	191.25	159.38	120.0
$C_2 \times K_3$	10.75	64.43	112.31	189.38	140.63	101.25
Cultivar x Potash levels C.D. (5%)	1.45	10.32	10.17	16.64	15.65	13.39

N.S.: Not significant

Among potash levels 40 (K_2) and 60 (K_3) kg ha^{-1} were on par but significantly superior over K_0 (0) and K_1 (20 kg ha^{-1}). Potash levels at K_1, K_2 and K_3 had recorded 62.7, 40.0 and 23.6 per cent more leaf dry weight over control.

Interaction between cultivars and potash levels was also significant. On 60 DAE cv. SPV-462 at 40 kg K_2O ha^{-1} recorded maximum leaf dry weight. In the case of cv. CSH-5, potash at 40 kg ha^{-1} recorded higher dry weight of leaves than other potash levels.

4.1.6 Dry Weight of Stems

The data on stem dry weight (g m^{-2}) (Table 6) increased throughout the crop growth period. The differences among cultivars were significant from 45 to 90 DAE. On 90 DAE, maximum stem dry weight was recorded. Cv. SPV-462 produced more dry weight than cv. CSH-5.

Among potash levels, 20 (K_1), 40 (K_2) and 60 (K_3) kg ha^{-1} were on par but significantly superior to control (K_0), 0 kg ha^{-1}. Potash at 40 kg ha^{-1} recorded maximum stem dry weight over control, the increase being 33.3 per cent.

Interaction between cultivars and potash levels was significant throughout the crop growth period. Cv. SPV-462 recorded maximum dry weight of stems. Cv. CSH-5

Table 6: Dry weight of stems ($g\ m^{-2}$) of sorghum cultivars as influenced by potash levels during 1988 rainy season

Treatments	DAYS AFTER EMERGENCE					
	15	30	45	60	75	90
Cultivar means						
SPV-462 (C_1)	3.83	41.35	80.70	517.50	582.65	646.72
CSH - 5 (C_2)	3.66	43.72	73.76	461.72	555.94	622.03
C.D. (5%)	NS	NS	4.92	29.79	18.57	13.21
Potash levels ($kg\ K_2O\ ha^{-1}$)						
0 (K_0)	3.16	37.03	50.28	385.31	478.13	549.38
20 (K_1)	3.25	40.27	60.18	446.25	559.68	645.00
40 (K_2)	4.51	51.26	102.84	577.50	637.50	689.06
60 (K_3)	4.06	41.59	95.63	549.37	601.88	654.06
C.D.(5%)	0.68	8.19	6.96	42.13	26.26	18.68
Treatment means						
$C_1 \times K_0$	3.85	36.46	53.28	406.88	476.25	541.87
$C_1 \times K_1$	3.47	41.49	59.10	472.50	566.25	654.38
$C_1 \times K_2$	4.34	49.28	109.30	605.63	661.88	706.88
$C_1 \times K_3$	3.67	38.18	101.13	585.00	626.25	683.75
$C_2 \times K_0$	2.49	37.60	47.29	363.75	480.00	556.88
$C_2 \times K_1$	3.04	39.03	61.26	420.00	553.13	635.63
$C_2 \times K_2$	4.68	53.25	96.38	549.38	613.13	671.25
$C_2 \times K_3$	4.44	45.01	90.14	513.75	577.50	624.38
Cultivar x Potash levels C.D. (5%)	0.96	11.58	9.84	59.57	37.13	26.42

N.S.: Not significant

at the same potash level of 40 kg ha^{-1} recorded more dry weight of stems than other potash levels.

4.1.7 Dry Weight of Earhead

Earhead dry weight $plant^{-1}$ (g) was recorded from 60 DAE (Table 7). Differences among cultivars were significant from 75 DAE. Cv. SPV-462 recorded more earhead dry weight over cv. CSH-5 on 90 DAE, the increase being 3.9 per cent.

Among potash level, 40 (K_2) kg ha^{-1} was significantly superior over the other 3 levels. Potash levels at 20 (K_1) and 60 (K_3) kg ha^{-1} recorded almost same dry weight of earheads, the increase being 30.6 and 24.4 per cent respectively over K_0.

Interaction between cultivars and potash levels were also significant. Cv. SPV-462 at 40 kg K_2O ha^{-1} recorded maximum dry weight of earheads per plant. Cv. CSH-5 at the same potash level recorded maximum dry weight of earheads over other 3 levels.

4.1.8 Total Dry Matter Produced

The data on the total dry matter produced (g m^{-2}) were furnished in (Table 8 & Fig. 4). Cv. SPV-462 produced more dry matter as compared to cv. CSH-5. Higher dry matter accumulation in cv. SPV-462 was observed from panicle emergence onwards (60 DAE).

Table 7: Dry weight of earheads (g m^{-2}) of sorghum cultivars as influenced by potash levels during 1988 rainy season

Treatments	DAYS AFTER EMERGENCE 60	75	90
Cultivar means			
SPV-462 (C_1)	133.13	296.72	392.81
CSH - 5 (C_2)	126.88	270.94	378.13
C.D. (5%)	NS	16.37	7.66
Potash levels ($kg\ K_2O\ ha^{-1}$)			
0 (K_0)	88.13	241.88	334.69
20 (K_1)	135.00	276.56	390.00
40 (K_2)	151.88	315.94	426.86
60 (K_3)	145.00	300.94	390.63
C.D.(5%)	11.98	23.15	10.83
Treatment means			
$C_1 \times K_0$	90.00	262.50	352.50
$C_1 \times K_1$	131.25	286.88	397.50
$C_1 \times K_2$	161..25	331.88	438.75
$C_1 \times K_3$	150.00	305.63	382.50
$C_2 \times K_0$	86.25	221.25	316.88
$C_2 \times K_1$	138.78	266.25	382.50
$C_2 \times K_2$	142.50	300.00	414.38
$C_2 \times K_3$	140.00	296.25	398.75
Cultivar x Potash levels C.D. (5%)	16.94	32.74	15.32

N.S.: Not significant

Table 8: Total dry matter produced (g m^{-2}) of sorghum cultivars as influenced by potash levels during 1988 rainy season

Treatments	DAYS AFTER EMERGENCE					
	15	30	45	60	75	90
Cultivar means						
SPV-462 (C_1)	11.0	111	177	836	1022	1144
CSH - 5 (C_2)	12.7	104	167	752	955	1099
C.D. (5%)	1.1	NS	NS	60	19	NS
Potash levels (kg K_2O ha^{-1})						
0 (K_0)	9.6	90	109	594	823	966
20 (K_1)	10.3	103	140	737	963	1129
40 (K_2)	14.1	126	228	946	1121	1241
60 (K_3)	13.2	111	211	898	1047	1150
C.D.(5%)	1.6	18	24	85	27	91
Treatment means						
$C_1 \times K_0$	10.3	90	114	621	849	979
$C_1 \times K_1$	10.5	111	140	761	990	1146
$C_1 \times K_2$	11.9	130	236	1008	1170	1276
$C_1 \times K_3$	11.2	112	219	956	1080	1176
$C_2 \times K_0$	9.0	90	105	568	797	954
$C_2 \times K_1$	10.1	95	139	713	937	1114
$C_2 \times K_2$	16.3	122	220	884	1072	1206
$C_2 \times K_3$	15.2	109	202	843	1014	1124
Cultivar x Potash levels C.D. (5%)	2.3	26	34	120	39	129

N.S.: Not significant

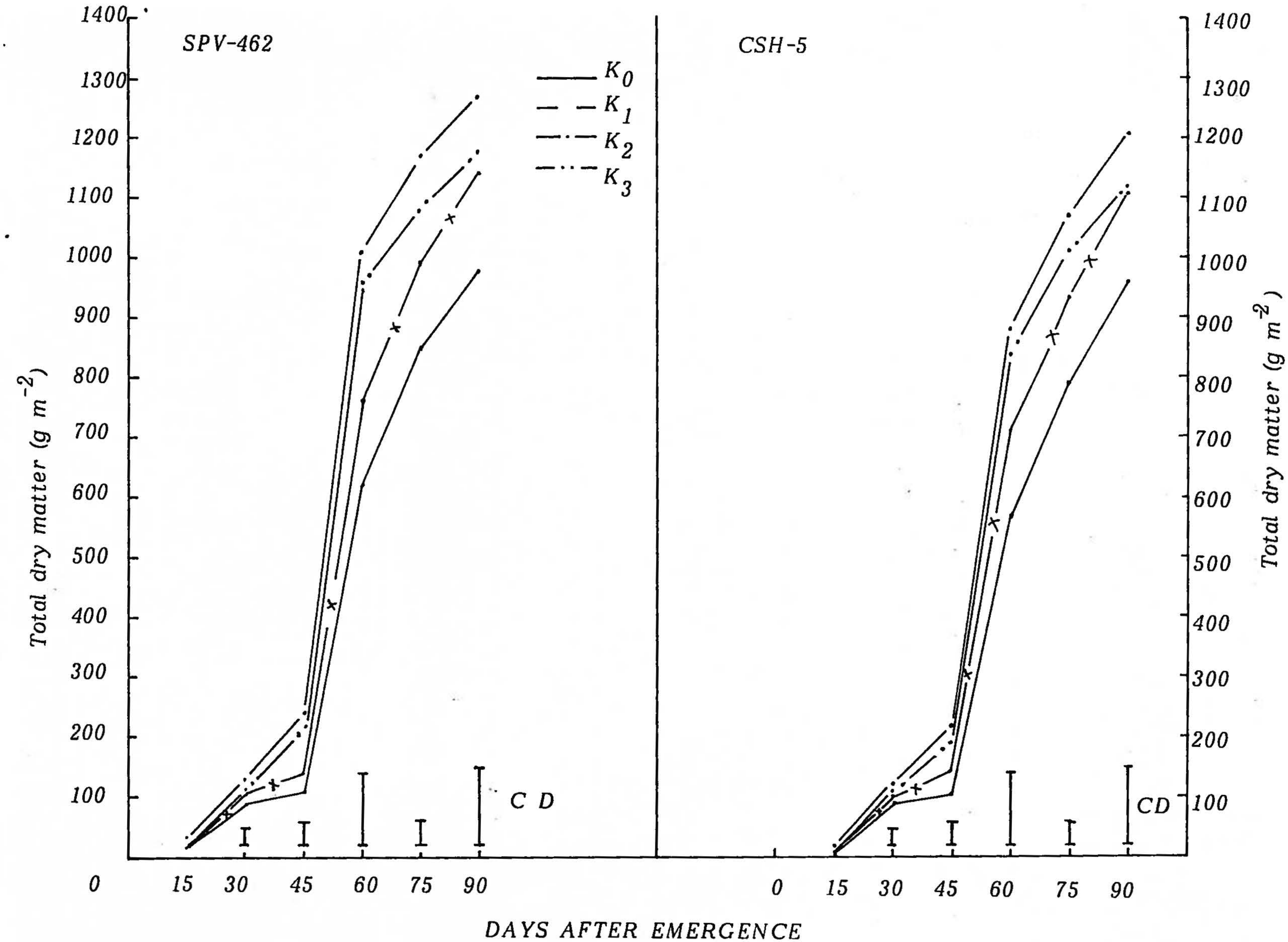


Fig. 4: Total dry matter (g m^{-2}) as influenced by potash levels in sorghum

Potash levels at 40 (K_2) and 60 (K_3) kg ha^{-1} were on par but significantly superior to 0 and 20 kg ha^{-1} on 90 DAE, the per cent increase being 28.5 and 19.0 respectively over control.

The interaction between cultivars and potash levels was also significant. Maximum dry matter production was recorded with cv. SPV-462 at 40 kg K_2O ha^{-1}. Cv. CSH-5 at the same potash level recorded maximum total dry matter over other potash levels.

4.1.9 Dry Matter Partitioning

The data on dry matter partitioning (%) were given in Table 9. The data revealed at 90 DAE, the dry matter partitioning was almost same among cultivars, potassium levels and their interaction. However, it was observed that more partitioning of dry matter took place into leaves with 40 kg K_2O ha^{-1}.

4.1.10 Leaf Area Index (LAI)

The data on Leaf Area Index (LAI) (Table 10 & Fig.5) showed that from 15 DAE, there was a continuous increase upto 60 DAE and decreased lateron.

There was no significant difference between the two cultivars, except at 45 DAE, where cv. CSH-5 was superior over cv. SPV-462.

Table 9: Dry matter partitioning (%) at 90 DAE of sorghum cultivars as influenced by potash levels during 1988 rainy season

Treatments	Leaves	Stem	Earhead
Cultivar means			
SPV-462 (C_1)	9.17	56.53	34.34
CSH - 5 (C_2)	9.04	56.60	34.41
Potash levels (kg K_2O ha^{-1})			
0 (K_0)	8.54	56.87	34.65
20 (K_1)	8.39	57.13	34.54
40 (K_2)	10.12	55.52	34.39
60 (K_3)	9.21	56.87	33.97
Treatment means			
$C_1 \times K_0$	8.62	55.35	36.01
$C_1 \times K_1$	8.18	57.10	34.68
$C_1 \times K_2$	10.29	55.40	34.38
$C_1 \times K_3$	9.41	58.14	32.52
$C_2 \times K_0$	8.45	58.37	33.21
$C_2 \times K_1$	8.58	57.06	34.33
$C_2 \times K_2$	9.95	55.66	34.36
$C_2 \times K_3$	9.01	55.55	35.47

N.S.: Not significant

Table 10: Leaf Area Index (LAI) of sorghum cultivars as influenced by potash levels during 1988 rainy season

Treatments	DAYS AFTER EMERGENCE					
	15	30	45	60	75	90
Cultivar means						
SPV-462 (C_1)	0.21	1.40	2.17	3.38	1.98	1.08
CSH - 5 (C_2)	0.23	1.32	2.62	3.56	1.98	1.10
C.D. (5%)	NS	NS	0.32	NS	NS	NS
Potash levels (kg K_2O ha^{-1})						
0 (K_0)	0.19	1.15	1.74	2.89	1.82	0.89
20 (K_1)	0.20	1.32	2.19	3.30	1.91	0.98
40 (K_2)	0.25	1.48	2.85	3.92	2.28	1.33
60 (K_3)	0.25	1.49	2.80	3.76	1.93	1.16
C.D.(5%)	0.04	NS	0.45	0.55	0.21	0.15
Treatment means						
$C_1 \times K_0$	0.19	1.17	1.40	2.60	1.85	0.89
$C_1 \times K_1$	0.21	1.45	1.86	3.04	1.89	0.91
$C_1 \times K_2$	0.22	1.49	2.73	4.09	2.27	1.38
$C_1 \times K_3$	0.22	1.48	2.70	3.78	1.91	1.15
$C_2 \times K_0$	0.18	1.11	2.09	3.18	1.79	0.90
$C_2 \times K_1$	0.20	1.20	2.52	3.55	1.93	1.06
$C_2 \times K_2$	0.27	1.48	2.97	3.76	2.28	1.28
$C_2 \times K_3$	0.28	1.49	2.89	3.74	1.95	1.17
Cultivar x Potash levels C.D. (5%)	0.06	NS	0.64	0.77	0.29	0.21

N.S.: Not significant

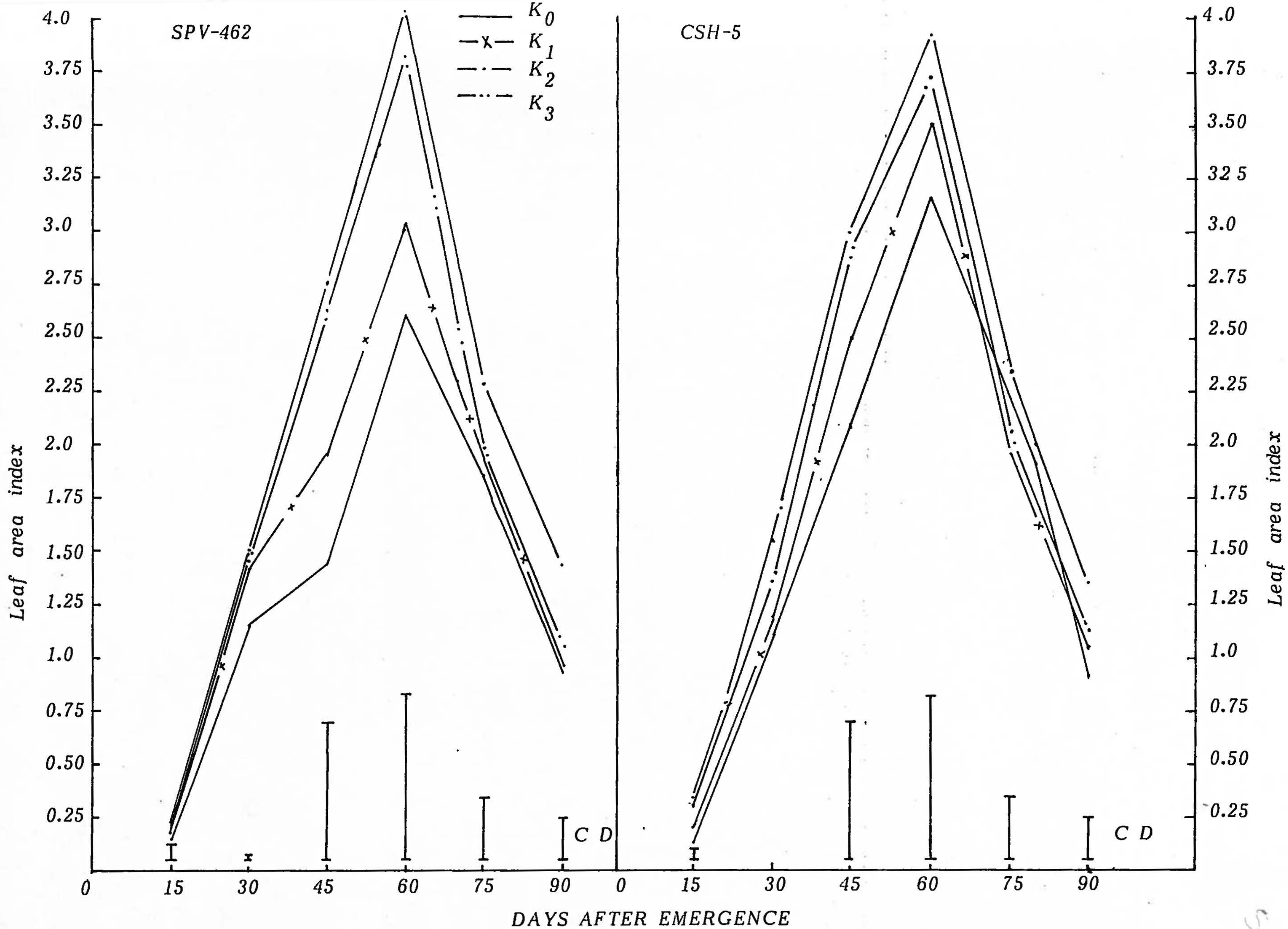


Fig. 5 : Leaf area index (LAI) as influenced by potash levels in sorghum

Potash levels significantly influenced the LAI. The sorghum crop recorded maximum LAI on 60 DAE. The potash levels at 40 (K_2) and 60 (K_3) kg ha^{-1} were on par but significantly superior over 0 kg ha^{-1} (K_0), the increase being 35.6 and 30.1 per cent respectively over control (K_0). The order of increase was: $K_2 > K_3 > K_1 > K_0$.

Interaction between cultivars and potash levels was also significant. Cv. SPV-462 at 40 kg K_20 ha^{-1} recorded maximum LAI. In cv. CSH-5, potash at 40 kg K_20 ha^{-1} recorded higher LAI over other potash levels.

4.1.11 Crop Growth Rate (CGR)

CGR (g m^{-2} day^{-1}) was recorded from 30 DAE to 90 DAE (Table 11 & Fig.6). At 45 DAE, it slightly reduced and maximum CGR was recorded at 60 DAE. Later it declined continuously. The two cultivars differed significantly except upto 45 DAE. Cv. SPV-462 was significantly superior to cv. CSH-5.

Potash levels differed significantly throughout the crop growth. Upto 60 DAE, potash level at 40 and 60 kg ha^{-1} was significantly superior over 0 and 20 kg K_20 ha^{-1}. But the trend was reversed at 75 and 90 DAE when potash level at 0 and 20 kg ha^{-1} recorded maximum CGR. At 60 DAE K_2, recorded 48 per cent more CGR over K_0 (control).

Table 11: Crop Growth Rate - CGR (g m^{-2} day^{-1}) of sorghum cultivars as influenced by potash levels during 1988 rainy season

Treatments	DAYS AFTER EMERGENCE				
	30	45	60	75	90
Cultivar means					
SPV-462 (C_1)	6.67	4.40	43.93	12.40	8.13
CSH - 5 (C_2)	6.09	4.20	39.00	13.53	9.60
C.D. (5%)	NS	NS	2.40	1.10	0.60
Potash levels (kg K_2O ha^{-1})					
0 (K_0)	5.36	1.27	32.33	15.27	9.53
20 (K_1)	6.18	2.47	39.80	15.07	11.07
40 (K_2)	7.46	6.80	47.87	11.67	8.00
60 (K_3)	6.50	6.67	45.80	9.93	6.87
C.D.(5%)	0.90	1.00	3.40	1.90	1.40
Treatment means					
$C_1 \times K_0$	5.31	1.60	33.80	15.20	8.67
$C_1 \times K_1$	6.70	1.93	41.40	15.27	10.40
$C_1 \times K_2$	7.87	7.07	51.46	10.80	7.07
$C_1 \times K_3$	6.72	7.13	49.13	8.27	6.40
$C_2 \times K_0$	5.40	1.00	30.87	15.27	10.47
$C_2 \times K_1$	5.66	2.93	38.27	14.93	11.80
$C_2 \times K_2$	7.05	6.53	44.27	12.53	8.93
$C_2 \times K_3$	6.25	6.20	42.73	11.40	7.33
Cultivar x Potash levels C.D. (5%)	1.20	1.80	4.30	2.80	2.50

N.S.: Not significant

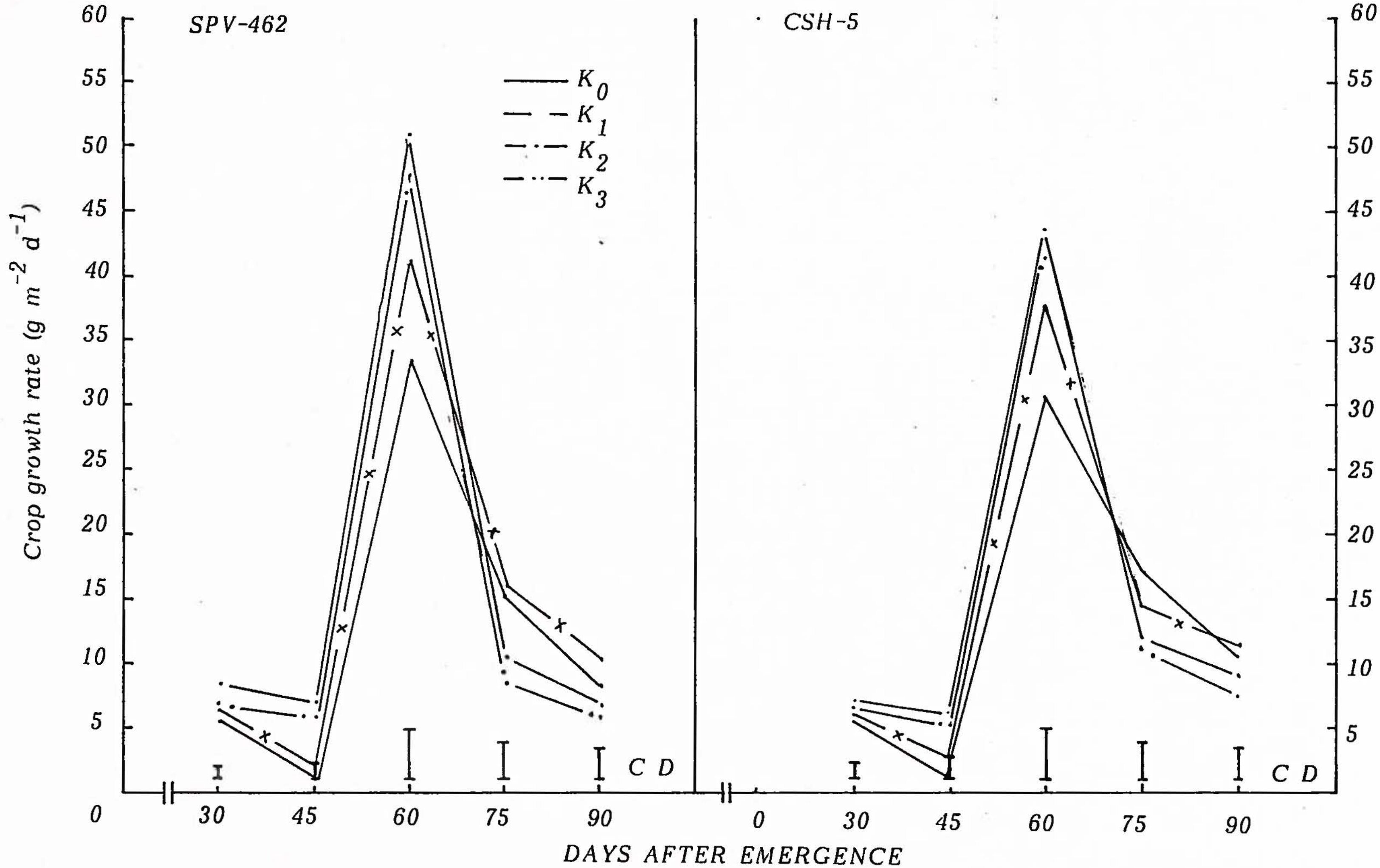


Fig. 6 : Crop growth rate (CGR) ($g\ m^{-2}\ d^{-1}$) in sorghum as influenced by potash levels

The interaction between cultivars and potash levels was also significant. Cv. SPV-462 at 40 kg K_2O ha^{-1} at 60 DAE recorded maximum CGR. Cv. CSH-5 also at the same potash level recorded more CGR over other three levels.

4.1.12 <u>Relative Growth Rate</u> (RGR)

Relative growth rate (RGR) (g g^{-1} day^{-1}) was recorded from 30 DAE to 90 DAE (Table 12). At 45 DAE, it slightly declined. Maximum RGR was recorded at 60 DAE and later it declined gradually upto 90 DAE. Cultivars did not differ significantly in RGR values.

Potash levels differed significantly except at 30 DAE. Potash level at 0 kg ha^{-1} on 60 DAE was found to be significantly superior to 40 and 60 kg ha^{-1}.

Potash and cultivar interaction was also significant. At 60 DAE, cv. SPV-462 at 0 and 20 kg K_2O recorded maximum RGR. Cv. CSH-5 at 0 kg K_2O ha^{-1} recorded more RGR over other three levels.

4.1.13 <u>Net Assimilation Rate</u> (NAR)

NAR (g m^{-2} day^{-1}) was recorded throughout the crop growth (Table 13). NAR decreased at 45 DAE. Maximum NAR values were recorded at 60 DAE. Later it decreased. At 90 DAE it slightly increased. Cultivars differed

Table 12: Relative Growth Rate - RGR (g g^{-1} day^{-1}) of sorghum cultivars as influenced by potash levels during 1988 rainy season

Treatments	DAYS AFTER EMERGENCE				
	30	45	60	75	90
Cultivar means					
SPV-462 (C_1)	0.154	0.030	0.103	0.013	0.008
CSH - 5 (C_2)	0.138	0.031	0.100	0.016	0.009
C.D. (5%)	0.010	NS	NS	NS	NS
Potash levels (kg K_2O ha^{-1})					
0 (K_0)	0.150	0.013	0.113	0.022	0.011
20 (K_1)	0.154	0.020	0.111	0.018	0.011
40 (K_2)	0.146	0.040	0.095	0.011	0.007
60 (K_3)	0.142	0.043	0.097	0.010	0.006
C.D.(5%)	NS	0.018	NS	0.007	0.004
Treatment means					
$C_1 \times K_0$	0.145	0.016	0.113	0.020	0.009
$C_1 \times K_1$	0.157	0.015	0.113	0.018	0.010
$C_1 \times K_2$	0.158	0.040	0.097	0.010	0.006
$C_1 \times K_3$	0.154	0.045	0.098	0.008	0.006
$C_2 \times K_0$	0.154	0.010	0.112	0.023	0.012
$C_2 \times K_1$	0.149	0.025	0.109	0.018	0.012
$C_2 \times K_2$	0.134	0.039	0.093	0.013	0.008
$C_2 \times K_3$	0.131	0.041	0.095	0.012	0.007
Cultivar x Potash levels					
C.D. (5%)	0.018	0.022	0.011	0.009	0.006

N.S.: Not significant

Table 13: Net Assimilation Rate - NAR (g m^{-2} day^{-1}) of sorghum cultivars as influenced by potash levels during 1988 rainy season

Treatments	DAYS AFTER EMERGENCE				
	30	45	60	75	90
Cultivar means					
SPV-462 (C_1)	10.63	2.50	16.10	4.74	5.48
CSH - 5 (C_2)	9.72	2.21	12.72	5.09	6.41
C.D. (5%)	NS	NS	0.83	0.11	0.41
Potash levels ($kg\ K_2O\ ha^{-1}$)					
0 (K_0)	10.13	0.89	14.26	6.59	7.33
20 (K_1)	10.33	1.44	14.70	5.93	7.94
40 (K_2)	10.84	3.24	14.26	3.86	4.54
60 (K_3)	9.40	3.21	14.06	3.62	4.54
C.D.(5%)	NS	0.35	NS	0.93	1.11
Treatment means					
$C_1 \times K_0$	9.72	1.25	17.43	6.90	6.61
$C_1 \times K_1$	9.28	1.17	17.23	4.15	7.76
$C_1 \times K_2$	11.90	3.45	15.29	3.49	3.95
$C_1 \times K_3$	10.24	3.51	15.31	3.02	4.27
$C_2 \times K_0$	10.51	0.64	11.89	6.31	8.09
$C_2 \times K_1$	10.25	1.65	12.68	5.59	8.13
$C_2 \times K_2$	9.83	3.05	13.74	4.24	5.15
$C_2 \times K_3$	8.62	2.93	12.96	4.15	4.80
Cultivar x Potash levels C.D. (5%)	NS	0.51	1.42	1.14	1.73

N.S.: Not significant

significantly except at 15 and 30 DAE. Cv. SPV-462 was found to be significantly superior to cv. CSH-5.

Potash levels differed significantly. At 45 DAE, potash level at 40 kg ha^{-1} was significantly superior over K_0 and K_1. Later K_0 and K_1 were on par but significantly superior to K_2 and K_3.

Interaction between cultivars and potash levels was also significant. At 60 DAE, where maximum NAR was recorded, cv. SPV-462 at 0 kg K_2O ha^{-1} recorded maximum NAR. Cv. CSH-5 at 40 kg K_2O ha^{-1} recorded more NAR over other three levels.

4.2 BIO-CHEMICAL PARAMETERS

4.2.1 <u>Nitrogen Concentration in Leaves, Stems and Earheads</u>

The data on nitrogen concentration in leaves, stems and earheads recorded during the entire crop growth period were found to be not significant (Table 14). However, the following trends were observed as to the N concentration in different plant parts. Concentration of N in sorghum leaves started declining from 15 DAE onwards. With increase in potash levels, there was increase in N concentration upto 30 DAE. Concentration of N in stems increased from 15 DAE to 30 DAE. Later it declined upto 90 DAE. With increase in K levels, N concentration increased upto 30 DAE. In sorghum ear-

Table 14: Nitrogen concentration (%) in different plant parts of sorghum cultivars as influenced by potash levels during 1988 rainy season

Treatment	DAYS AFTER EMERGENCE: 15		30		45		60			75			90		
	L	S	L	S	L	S	L	S	E	L	S	E	L	S	E
Cultivar means															
SPV-462 (C_1)	2.98	2.46	2.72	2.60	2.42	1.72	2.15	1.49	1.75	2.13	1.40	1.70	2.01	1.32	1.63
CSH - 5 (C_2)	3.00	2.60	2.70	2.61	2.38	1.89	2.19	1.43	1.73	2.13	1.36	1.70	2.03	1.26	1.62
C.D. (5%)	NS	NS	NS	NS	NS	0.15	NS	NS	NS	NS	NS	NS	NS	NS	NS
Potash levels ($kg\ K_2O\ ha^{-1}$)															
0 (K_0)	2.89	2.48	2.63	2.56	2.40	2.08	2.13	1.47	1.76	2.17	1.37	1.73	2.06	1.28	1.62
20 (K_1)	3.00	2.48	2.67	2.56	2.36	1.81	2.10	1.52	1.71	2.07	1.43	1.67	2.00	1.32	1.63
40 (K_2)	3.07	2.56	2.73	2.62	2.38	1.66	2.16	1.38	1.68	2.08	1.32	1.62	1.98	1.26	1.57
60 (K_3)	3.01	2.60	2.81	2.70	2.42	1.67	2.27	1.46	1.81	2.20	1.40	1.77	2.05	1.31	1.68
C.D. (5%)	NS	NS	NS	NS	NS	0.21	NS	NS	NS	NS	NS	NS	NS	NS	NS
Treatment means															
$C_1 \times K_0$	2.87	2.33	2.52	2.42	2.40	1.77	2.12	1.47	1.80	2.10	1.35	1.77	2.02	1.25	1.70
$C_1 \times K_1$	3.13	2.35	2.68	2.52	2.37	1.90	2.17	1.52	1.72	2.12	1.42	1.65	2.02	1.37	1.62
$C_1 \times K_2$	3.08	2.57	2.82	2.67	2.42	1.55	2.15	1.47	1.70	2.07	1.37	1.60	1.95	1.32	1.55
$C_1 \times K_3$	2.85	2.63	2.90	2.80	2.50	1.67	2.15	1.50	1.80	2.25	1.45	1.77	2.07	1.35	1.67
$C_2 \times K_0$	2.90	2.65	2.76	2.70	2.40	2.40	2.15	1.47	1.72	2.25	1.40	1.70	2.10	1.32	1.55
$C_2 \times K_1$	2.88	2.63	2.70	2.60	2.35	1.72	2.02	1.52	1.70	2.02	1.45	1.70	1.97	1.27	1.65
$C_2 \times K_2$	3.08	2.55	2.85	2.57	2.35	1.77	2.17	1.30	1.67	2.10	1.27	1.65	2.02	1.20	1.60
$C_2 \times K_3$	3.17	2.57	2.72	2.60	2.35	1.67	2.40	1.42	1.82	2.15	1.35	1.77	2.02	1.27	1.70
Cultivar x Potash levels C.D. (5%)	NS	0.23	NS	NS	NS	0.24	NS	NS	NS	NS	NS	NS	NS	NS	NS

N.S.: Not significant; L = Leaves; S = Stems; E = Earheads

heads, N concentration decreased from 60 DAE to 90 DAE, and there was no good trend with increasing potash levels.

4.2.2 Nitrogen concentration in the Whole Plant

Differences in N concentration in the whole plant (Table 15) were found to be not significant between the cultivars and among potash levels. N concentration declined from 15 DAE onwards.

4.2.3 Nitrogen Uptake by Leaves

Differences in N uptake by sorghum cultivars (kg ha^{-1}) were significant from 15 to 75 DAE (Table 16). In cv. SPV-462 uptake was more than in cv. CSH-5. N uptake increased from 15 to 60 DAE and then started to decline. N uptake by sorghum leaves differed significantly among the potash levels. Maximum N uptake was recorded at 60 DAE and potash level at 40 and 60 kg K_2O ha^{-1} were on par but significantly superior to 0 and 20 kg K_2O ha^{-1}.

Interaction between cultivars and potash levels was also significant throughout the crop growth period. Cv. SPV-462 recorded maximum N uptake by leaves at 40 kg K_2O ha^{-1}. Cv. CSH-5 at the potash level of 60 kg K_2O ha^{-1} recorded more N uptake over other potash levels.

Table 15: N-concentration (%) in whole plant of sorghum cultivars as influenced by potash levels during 1988 rainy season

Treatments	DAYS AFTER EMERGENCE					
	15	30	45	60	75	90
Cultivar means						
SPV-462 (C_1)	2.81	2.68	2.10	1.68	1.59	1.49
CSH - 5 (C_2)	2.90	2.71	2.13	1.65	1.59	1.47
C.D. (5%)	NS	NS	NS	NS	NS	NS
Potash levels (kg K_2O ha^{-1})						
0 (K_0)	2.79	2.62	2.26	1.65	1.58	1.46
20 (K_1)	2.95	2.65	2.11	1.68	1.58	1.48
40 (K_2)	2.97	2.76	2.05	1.61	1.52	1.44
60 (K_3)	2.87	2.77	2.09	1.70	1.62	1.51
C.D.(5%)	NS	NS	NS	NS	NS	NS
Treatment means						
$C_1 \times K_0$	2.77	2.50	2.09	1.65	1.58	1.48
$C_1 \times K_1$	2.90	2.63	2.17	1.69	1.58	1.51
$C_1 \times K_2$	2.91	2.77	2.02	1.67	1.54	1.46
$C_1 \times K_3$	2.76	2.89	2.12	1.69	1.65	1.53
$C_2 \times K_0$	2.82	2.74	2.40	1.70	1.58	1.46
$C_2 \times K_1$	2.98	2.67	2.08	1.66	1.59	1.46
$C_2 \times K_2$	2.90	2.75	2.09	1.55	1.50	1.42
$C_2 \times K_3$	2.99	2.68	2.06	1.71	1.72	1.49
Cultivar x Potash levels C.D. (5%)	NS	NS	NS	NS	NS	NS

N.S.: Not significant

Table 16: N-uptake (kg ha^{-1}) by leaves of sorghum cultivars as influenced by potash levels during 1988 rainy season

Treatments	DAYS AFTER EMERGENCE 15	30	45	60	75	90
Cultivar means						
SPV-462 (C_1)	2.15	19.03	23.40	40.00	30.45	21.11
CSH - 5 (C_2)	2.74	16.78	22.03	35.83	27.36	20.17
C.D. (5%)	0.21	1.40	NS	1.80	1.71	NS
Potash levels (kg K_2O ha^{-1})						
0 (K_0)	1.90	14.10	14.15	25.76	22.38	16.99
20 (K_1)	2.23	16.85	18.75	32.88	26.39	18.89
40 (K_2)	2.96	21.32	29.85	46.78	34.90	24.92
60 (K_3)	2.74	19.54	28.11	46.60	31.76	21.68
C.D.(5%)	0.31	1.98	1.72	2.55	2.36	1.89
Treatment means						
$C_1 \times K_0$	1.90	13.72	14.46	26.24	23.23	17.04
$C_1 \times K_1$	2.23	18.69	19.18	34.18	28.98	18.93
$C_1 \times K_2$	2.34	22.82	30.73	52.00	36.48	25.59
$C_1 \times K_3$	2.13	21.66	29.60	47.57	33.33	22.90
$C_2 \times K_0$	1.88	14.56	13.85	25.39	21.52	16.93
$C_2 \times K_1$	2.22	15.24	18.33	31.34	23.86	18.89
$C_2 \times K_2$	3.54	19.83	29.11	41.50	33.47	24.24
$C_2 \times K_3$	3.40	17.52	26.63	42.23	30.24	20.45
Cultivar x Potash levels C.D. (5%)	0.43	2.83	2.43	3.6	3.34	2.71

N.S.: Not significant

4.2.4 Nitrogen Uptake by Stems

The data recorded on N uptake by stems (Table 17) of sorghum cultivars (kg ha^{-1}) throughout the growth period revealed that the cultivars differed significantly from 60 DAE to 90 DAE. Cv. SPV-462 recorded more N uptake than cv. CSH-5 N uptake by stems was maximum at 90 DAE for both the cultivars.

The results revealed that among potash levels there was significant difference throughout the growth period. Upto 45 DAE, potash levels at 0 and 20 kg ha^{-1} were on par but significantly inferior to 40 kg K_2O ha^{-1} which was superior to 60 kg K_2O ha^{-1}. From 60 DAE upto the end of plant growth period, 40 and 60 kg K_2O ha^{-1} were on par and were superior to 0 and 20 kg K_2O ha^{-1} and at the same age of the plant 20 kg K_2O ha^{-1} was significantly superior to 0 kg K_2O ha^{-1}.

Interaction between cultivar and potash levels was also significant. Cv. SPV-462 at 60 kg K_2O ha^{-1} recorded maximum uptake closely followed by 40 kg K_2O ha^{-1}. In cv. CSH-5, potash level at 20 kg K_2O ha^{-1} recorded more N uptake by stems though it was on par with 40 and 60 kg K_2O ha^{-1}.

4.2.5 Nitrogen Uptake by Earheads

N uptake by earheads (Table 18) among cultivars (kg ha^{-1}) differed significantly from 75 to 90 DAE.

Table 17: N-uptake (kg ha^{-1}) by stems of sorghum cultivars as influenced by potash levels during 1988 rainy season

Treatments	DAYS AFTER EMERGENCE 15	30	45	60	75	90
Cultivar means						
SPV-462 (C_1)	0.94	10.75	13.88	77.11	81.57	85.36
CSH - 5 (C_2)	0.95	11.41	13.94	66.03	75.75	78.37
C.D. (5%)	NS	NS	NS	4.3	2.56	1.70
Potash levels (kg K_2O ha^{-1})						
0 (K_0)	0.78	9.48	10.46	56.64	65.50	70.32
20 (K_1)	0.81	10.42	10.89	67.83	80.03	85.14
40 (K_2)	1.15	13.42	17.00	79.69	84.15	86.92
60 (K_3)	1.05	11.19	15.98	80.21	84.26	86.48
C.D.(5%)	0.17	2.14	1.26	6.14	3.62	2.42
Treatment means						
C_1 x K_0	0.89	8.82	9.43	59.81	64.30	67.72
C_1 x K_1	0.82	10.46	11.23	71.82	80.41	89.65
C_1 x K_2	1.12	13.16	16.94	89.03	90.68	93.31
C_1 x K_3	0.96	10.69	16.92	87.75	90.81	93.66
C_2 x K_0	0.66	10.15	11.35	56.41	67.20	73.51
C_2 x K_1	0.79	10.15	10.54	63.84	80.20	80.72
C_2 x K_2	1.19	13.69	17.06	71.42	77.87	80.55
C_2 x K_3	1.14	11.70	15.05	72.95	77.71	79.30
Cultivar x Potash levels C.D. (5%)	0.24	2.61	1.78	8.69	5.13	3.42

N.S.: Not significant

Table 18: N-uptake by earheads (kg ha^{-1}) of sorghum cultivars as influenced by potash levels during 1988 rainy season

Treatments	DAYS AFTER EMERGENCE		
	60	75	90
Cultivar means			
SPV-462 (C_1)	23.29	50.44	64.03
CSH - 5 (C_2)	21.95	46.06	61.26
C.D. (5%)	NS	2.78	1.24
Potash levels (kg K_2O ha^{-1})			
0 (K_0)	15.51	41.85	54.22
20 (K_1)	23.08	46.18	63.57
40 (K_2)	25.52	51.18	67.02
60 (K_3)	26.25	53.27	65.83
C.D.(5%)	2.08	3.93	1.76
Treatment means			
$C_1 \times K_0$	16.20	46.46	59.93
$C_1 \times K_1$	22.57	47.33	64.39
$C_1 \times K_2$	27.41	53.10	68.01
$C_1 \times K_3$	27.00	54.09	63.87
$C_2 \times K_0$	14.83	37.61	49.12
$C_2 \times K_1$	23.59	45.26	63.11
$C_2 \times K_2$	23.79	49.50	66.30
$C_2 \times K_3$	25.48	52.44	67.79
Cultivar x Potash levels			
C.D. (5%)	2.95	5.53	2.50

N.S.: Not significant

Cv. SPV-462 recorded more N uptake by earheads than cv. CSH-5. Maximum N uptake was recorded on 90 DAE. Among potash levels, the differences were significant from 60 to 90 DAE. Potash level at 60 kg ha^{-1} recorded more N uptake on 60 and 75 DAE whereas at 90 DAE, 40 kg K_2O ha^{-1} recorded more N uptake, the increase being 23.61 per cent over control at 90 DAE.

Interaction between cultivars and potash levels was also significant. Cv. SPV-462 at 40 kg K_2O ha^{-1} recorded maximum N uptake. Cv. CSH-5 at 60 kg K_2O ha^{-1} recorded higher N uptake over other potash levels.

4.2.6 <u>Nitrogen Uptake by Whole Plant</u>

Differences in N uptake (kg ha^{-1}) by the whole plant (Table 19) was significant among the two cultivars from 60 DAE to 75 DAE. N uptake was increased from 15 DAE to 90 DAE. Cv. SPV-462 recorded more N uptake than cv. CSH-5. Maximum N uptake was recorded on 90 DAE.

Differences in N uptake by the whole plant among potash levels were found to be significant. Potash level at 40 kg ha^{-1} recorded more N uptake than control, the increase being 26.4 per cent whereas K_3 and K_1 (60 and 20 kg K_2O ha^{-1}) recorded 23.2 and 18.2 per cent more N uptake over control respectively.

Interaction between cultivars and potash levels was also significant throughout the growth period. Cv.

Table 19: Total N-uptake (kg ha^{-1}) by sorghum cultivars as influenced by potash levels during 1988 rainy season

Treatments	DAYS AFTER EMERGENCE 15	30	45	60	75	90
Cultivar means						
SPV-462 (C_1)	3.09	29.78	37.27	140.40	162.46	170.50
CSH - 5 (C_2)	3.69	28.19	35.60	123.81	152.60	161.20
C.D. (5%)	0.32	NS	NS	10.60	3.00	NS
Potash levels (kg K_2O ha^{-1})						
0 (K_0)	2.68	23.58	24.61	97.91	129.73	141.53
20 (K_1)	3.04	27.27	28.61	123.79	152.60	167.60
40 (K_2)	4.19	34.74	46.85	151.99	170.23	178.86
60 (K_3)	3.79	30.73	44.09	153.06	169.23	173.99
C.D.(5%)	0.46	4.87	5.16	14.53	4.27	13.67
Treatment means						
C_1 x K_0	2.79	22.54	23.92	102.25	133.99	144.69
C_1 x K_1	3.05	29.15	30.41	128.57	156.72	172.97
C_1 x K_2	3.46	35.98	47.67	168.44	180.26	186.91
C_1 x K_3	3.09	32.35	46.52	162.32	178.23	180.43
C_2 x K_0	2.54	24.71	25.20	96.63	126.33	139.56
C_2 x K_1	3.01	25.39	28.87	118.77	149.32	162.72
C_2 x K_2	4.73	33.52	46.17	136.71	160.84	171.09
C_2 x K_3	4.54	29.22	41.68	143.88	174.84	167.54
Cultivar x Potash levels C.D. (5%)	0.61	7.22	7.54	20.67	6.18	19.41

N.S.: Not significant

SPV-462 recorded more N uptake at 40 kg K_2O ha^{-1} followed by cv. CSH-5 at the same potash level.

4.2.7 Phosphorus Concentration in Leaves, Stems and Earheads

The data on phosphorus concentration (%) in leaves, stems and earheads (Table 20) recorded during the entire crop growth period revealed that there was no significant difference in P concentration among various plant parts. But the following trends were observed. P concentration in leaves declined from 15 to 90 DAE and the same was found to be decreased with increased K level from 30 DAE onwards. P concentration in stems also decreased from 15 DAE to 90 DAE. There was no significant difference among the cultivars and potash levels except at 45 DAE. Interaction between cultivars and potash levels was also not significant except on 45 DAE.

4.2.8 Phosphorus Uptake by Leaves

P uptake by leaves (kg ha^{-1}) of sorghum cultivars (Table 22) differed significantly except at 45 and 90 DAE. P uptake increased from 15 DAE to 60 DAE and later it declined. Cv. SPV-462 recorded more P uptake than cv. CSH-5.

Among potash levels the differences in P uptake were significant from 15 DAE to 90 DAE. Potash level

Table 20: Phosphorus concentration (%) in different plant parts of sorghum cultivars as influenced by potash levels during 1988 rainy season

Treatment	DAYS AFTER EMERGENCE														
	15		30		45		60			75			90		
	L	S	L	S	L	S	L	S	E	L	S	E	L	S	E
Cultivar means															
SPV-462 (C_1)	0.386	0.370	0.368	0.364	0.289	0.294	0.233	0.169	0.278	0.231	0.165	0.283	0.223	0.159	0.273
CSH - 5 (C_2)	0.399	0.386	0.364	0.363	0.276	0.273	0.231	0.167	0.274	0.232	0.175	0.299	0.222	0.164	0.281
C.D. (5%)	NS	0.010	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Potash levels ($kg\ K_2O\ ha^{-1}$)															
0 (K_0)	0.385	0.364	0.368	0.368	0.293	0.305	0.241	0.178	0.290	0.234	0.176	0.298	0.226	0.168	0.283
20 (K_1)	0.395	0.383	0.376	0.371	0.274	0.289	0.234	0.171	0.280	0.223	0.175	0.307	0.224	0.165	0.280
40 (K_2)	0.389	0.379	0.360	0.358	0.273	0.263	0.228	0.163	0.271	0.230	0.168	0.283	0.219	0.158	0.275
60 (K_3)	0.400	0.388	0.359	0.359	0.280	0.278	0.225	0.160	0.263	0.230	0.161	0.278	0.220	0.156	0.271
C.D.(5%)	NS	NS	NS	NS	NS	0.038	NS	NS	NS	NS	NS	NS	NS	NS	NS
Treatment means															
$C_1 \times K_0$	0.375	0.358	0.375	0.375	0.290	0.320	0.243	0.180	0.293	0.235	0.170	0.293	0.230	0.163	0.283
$C_1 \times K_1$	0.380	0.365	0.375	0.368	0.280	0.318	0.235	0.173	0.280	0.230	0.170	0.288	0.223	0.165	0.280
$C_1 \times K_2$	0.385	0.373	0.365	0.360	0.278	0.270	0.228	0.163	0.273	0.230	0.160	0.278	0.218	0.150	0.270
$C_1 \times K_3$	0.403	0.385	0.358	0.355	0.288	0.270	0.228	0.160	0.265	0.230	0.160	0.275	0.220	0.160	0.263
$C_2 \times K_0$	0.395	0.370	0.360	0.360	0.295	0.290	0.240	0.175	0.288	0.233	0.183	0.303	0.223	0.173	0.283
$C_2 \times K_1$	0.410	0.400	0.378	0.375	0.268	0.260	0.233	0.170	0.280	0.235	0.180	0.325	0.225	0.165	0.280
$C_2 \times K_2$	0.393	0.385	0.355	0.355	0.268	0.255	0.228	0.163	0.270	0.230	0.175	0.288	0.220	0.165	0.280
$C_2 \times K_3$	0.398	0.390	0.363	0.363	0.273	0.285	0.223	0.160	0.260	0.230	0.163	0.280	0.220	0.153	[illegible]
Cultivar x Potash levels C.D. (5%)	NS	NS	NS	NS	NS	0.054	NS	NS	NS	NS	NS	NS	NS	NS	NS

N.S.: Not significant; L = Leaves; S = Stems; E = Earheads

Table 21: P concentration (%) of whole plant of sorghum cultivars as influenced by potash levels during 1988 rainy season

Treatments	DAYS AFTER EMERGENCE 15	30	45	60	75	90
Cultivar means						
SPV-462 (C_1)	0.38	0.36	0.29	0.19	0.21	0.21
CSH - 5 (C_2)	0.39	0.37	0.28	0.21	0.21	0.20
C.D. (5%)	NS	NS	NS	NS	NS	NS
Potash levels ($kg\ K_2O\ ha^{-1}$)						
0 (K_0)	0.38	0.36	0.31	0.22	0.22	0.21
20 (K_1)	0.41	0.37	0.27	0.21	0.22	0.21
40 (K_2)	0.39	0.38	0.27	0.19	0.21	0.21
60 (K_3)	0.39	0.35	0.29	0.19	0.20	0.20
C.D.(5%)	NS	NS	NS	NS	NS	NS
Treatment means						
$C_1 \times K_0$	0.38	0.41	0.30	0.20	0.22	0.21
$C_1 \times K_1$	0.38	0.37	0.29	0.20	0.21	0.21
$C_1 \times K_2$	0.38	0.37	0.27	0.19	0.20	0.21
$C_1 \times K_3$	0.39	0.36	0.31	0.19	0.21	0.20
$C_2 \times K_0$	0.38	0.36	0.32	0.24	0.23	0.21
$C_2 \times K_1$	0.44	0.38	0.26	0.23	0.23	0.21
$C_2 \times K_2$	0.39	0.40	0.28	0.19	0.21	0.20
$C_2 \times K_3$	0.39	0.36	0.26	0.19	0.22	0.20
Cultivar x Potash levels C.D. (5%)	NS	NS	NS	NS	NS	NS

N.S.: Not significant

Table 22: Phosphorus uptake by leaves kg ha^{-1} of sorghum cultivars as influenced by potash levels during 1988 rainy season

Treatments	DAYS AFTER EMERGENCE					
	15	30	45	60	75	90
Cultivar means						
SPV-462 (C_1)	0.28	2.57	2.75	4.34	3.31	2.34
CSH - 5 (C_2)	0.36	2.21	2.56	3.77	2.96	2.20
C.D. (5%)	0.03	0.19	NS	0.19	0.18	NS
Potash levels (kg K_2O ha^{-1})						
0 (K_0)	0.25	1.97	1.73	2.91	2.41	1.86
20 (K_1)	0.29	2.37	2.18	3.66	2.97	2.12
40 (K_2)	0.38	2.70	3.42	4.93	3.85	2.75
60 (K_3)	0.36	2.50	3.21	4.61	3.32	2.33
C.D.(5%)	0.05	0.27	0.20	0.27	0.25	0.21
Treatment means						
$C_1 \times K_0$	0.25	2.04	1.75	3.01	2.59	1.94
$C_1 \times K_1$	0.27	2.62	2.26	3.70	3.14	2.09
$C_1 \times K_2$	0.29	2.95	3.52	5.52	4.05	2.86
$C_1 \times K_3$	0.30	2.67	3.40	5.04	3.40	2.43
$C_2 \times K_0$	0.25	1.89	1.70	2.83	2.23	1.79
$C_2 \times K_1$	0.32	2.13	2.08	3.63	2.77	2.15
$C_2 \times K_2$	0.46	2.46	3.32	4.36	3.06	2.64
$C_2 \times K_3$	0.43	2.33	3.06	4.22	3.23	2.22
Cultivar x Potash levels C.D. (5%)	0.08	0.38	0.29	0.39	0.36	0.30

N.S.: Not significant

at 40 kg K_2O ha^{-1} was significantly superior over other three levels from 45 DAE. Increase in P uptake was 69.41 per cent over control at 60 DAE. The order of increase was: $K_2 > K_3 > K_1 > K_0$.

Interaction between cultivars and potash levels was also significant throughout the crop growth period. Cv. SPV-462 at 40 kg K_2O ha^{-1} recorded maximum P uptake. Cv. CSH-5 at 40 kg K_2O ha^{-1} recorded more P uptake over other three levels.

4.2.9 Phosphorus Uptake by Stems

The data on P uptake by stems (kg ha^{-1}) (Table 23) showed that there was no significant difference among cultivars except at 45 and 60 DAE. P uptake by stems recorded an increasing trend from 15 DAE to 90 DAE. P uptake was maximum at 90 DAE. Among potash levels, significant differences were obtained in P uptake. Potash level at 40 kg ha^{-1} recorded more P uptake. The increase in P uptake by K_1, K_2 and K_3 over control was 15.3, 17.9 and 10.5 per cent respectively at 90 DAE.

Interaction between cultivars and potash levels was also significant. Cv. CSH-5 at 40 kg K_2O ha^{-1} recorded maximum P uptake. In the case of cv. SPV-462, more P uptake was obtained at 40 kg K_2O ha^{-1} over other three levels.

Table 23: P-uptake by stems (kg ha^{-1}) in sorghum cultivars as influenced by potash levels during 1988 rainy season

Treatments	DAYS AFTER EMERGENCE 15	30	45	60	75	90
Cultivar means						
SPV-462 (C_1)	0.14	1.51	2.37	8.75	9.61	10.28
CSH - 5 (C_2)	0.14	1.58	2.01	7.70	9.73	10.20
C.D. (5%)	NS	NS	0.14	0.50	NS	NS
Potash levels (kg K_2O ha^{-1})						
0 (K_0)	0.12	1.36	1.54	6.86	8.42	9.23
20 (K_1)	0.12	1.49	1.74	7.63	9.79	10.64
40 (K_2)	0.17	1.84	2.71	9.41	10.71	10.88
60 (K_3)	0.16	1.49	2.66	8.78	9.69	10.20
C.D.(5%)	0.03	0.30	0.20	0.71	0.45	0.30
Treatment means						
$C_1 \times K_0$	0.14	1.37	1.70	7.32	8.09	8.83
$C_1 \times K_1$	0.13	1.53	1.87	8.17	9.63	10.79
$C_1 \times K_2$	0.16	1.77	2.95	9.87	10.59	10.60
$C_1 \times K_3$	0.14	1.36	2.73	9.36	10.02	10.94
$C_2 \times K_0$	0.09	1.35	1.37	6.36	8.78	9.63
$C_2 \times K_1$	0.12	1.46	1.59	7.14	9.95	10.48
$C_2 \times K_2$	0.18	1.89	2.45	8.95	10.73	11.08
$C_2 \times K_3$	0.17	1.63	2.29	8.22	11.04	9.55
Cultivar x Potash levels C.D. (5%)	0.03	0.42	0.28	1.0	0.63	0.43

N.S.: Not significant

4.2.10 Phosphorus Uptake by Earheads

P uptake by sorghum earheads (kg ha^{-1}) (Table 24) was not significant among the two cultivars. It increased from 60 to 90 DAE and maximum uptake was recorded at 90 DAE. Among the potash levels, the differences in P uptake by earheads were significant from 60 to 90 DAE. Potash level at 40 kg ha^{-1} was significantly superior to the rest of three levels at 90 DAE, the increase being 23.9 per cent over control.

Interaction between cultivars and potash levels was also significant. Cv. SPV-462 at 40 kg K_2O ha^{-1} recorded maximum P uptake by earheads. In the case of cv. CSH-5, 40 kg K_2O ha^{-1} recorded more P uptake by earheads.

4.2.11 Phosphorus Uptake by Whole Plant

P uptake by the whole plant (kg ha^{-1}) increased from 15 DAE to 90 DAE (Table 25). Differences in P uptake among cultivars differed significantly except at 30 and 90 DAE. Cv. SPV-462 recorded more P uptake than cv. CSH-5. Among potash levels, the differences in P uptake by the whole plant were significant from 15 to 90 DAE and potash at 40 kg K_2O ha^{-1} showed the highest total uptake.

Table 24: P-uptake by earheads (kg ha^{-1}) of sorghum cultivars as influenced by potash levels during 1988 rainy season

Treatments	DAYS AFTER EMERGENCE		
	60	75	90
Cultivar means			
SPV-462 (C_1)	3.70	8.39	10.72
CSH - 5 (C_2)	3.47	8.10	10.62
C.D. (5%)	NS	NS	NS
Potash levels (kg K_2O ha^{-1})			
0 (K_0)	2.55	7.20	9.47
20 (K_1)	3.78	8.49	10.92
40 (K_2)	4.12	8.94	11.73
60 (K_3)	3.81	8.36	10.58
C.D.(5%)	0.33	0.67	0.30
Treatment means			
$C_1 \times K_0$	2.63	7.69	9.97
$C_1 \times K_1$	3.67	8.26	11.13
$C_1 \times K_2$	4.40	9.22	11.84
$C_1 \times K_3$	3.97	8.40	10.05
$C_2 \times K_0$	2.48	6.70	8.96
$C_2 \times K_1$	3.88	8.65	10.71
$C_2 \times K_2$	3.84	8.64	11.60
$C_2 \times K_3$	3.64	8.29	11.16
Cultivar x Potash levels			
C.D. (5%)	0.47	0.95	0.42

N.S.: Not significant

Table 25: P-uptake by the whole plant (kg ha^{-1}) in sorghum cultivars as influenced by potash levels during 1988 rainy season

Treatments	DAYS AFTER EMERGENCE					
	15	30	45	60	75	90
<u>Cultivar means</u>						
SPV-462 (C_1)	0.42	4.15	5.04	16.54	21.31	23.34
CSH - 5 (C_2)	0.50	3.79	4.47	14.96	21.16	23.02
C.D. (5%)	0.04	NS	0.50	1.20	0.40	NS
<u>Potash levels</u> (kg K_2O ha^{-1})						
0 (K_0)	0.37	3.33	3.27	12.24	18.04	20.56
20 (K_1)	0.41	3.86	3.92	15.10	21.25	23.50
40 (K_2)	0.55	4.53	6.13	18.46	23.50	25.36
60 (K_3)	0.52	3.95	5.75	17.20	22.19	23.11
C.D.(5%)	0.06	0.66	0.68	1.72	0.57	1.89
<u>Treatment means</u>						
$C_1 \times K_0$	0.39	3.78	3.45	12.67	18.57	20.74
$C_1 \times K_1$	0.40	4.10	4.13	15.54	21.03	24.01
$C_1 \times K_2$	0.45	4.72	6.47	19.79	23.86	25.30
$C_1 \times K_3$	0.44	4.03	6.13	18.37	21.82	23.58
$C_2 \times K_0$	0.34	3.24	3.07	12.02	17.71	20.38
$C_2 \times K_1$	0.44	3.59	3.67	14.65	21.37	23.34
$C_2 \times K_2$	0.65	4.35	5.77	17.15	23.03	24.34
$C_2 \times K_3$	0.60	3.96	5.38	16.08	22.56	29.93
<u>Cultivar x Potash levels</u> C.D. (5%)	0.09	0.98	0.97	2.45	0.84	2.66

N.S.: Not significant

Interaction between the cultivars and potash levels was also significant. Cv. SPV-462 at 40 kg K_2O ha^{-1} recorded maximum values. In respect of cv. CSH-5, potash at 40 kg K_2O ha^{-1} recorded more uptake over other three levels.

4.2.12 Potassium Concentration in Leaves, Stems and Earheads

The differences in potassium concentration (%) in different plant parts like leaves, stems and earheads were not significant except in few samplings in leaves (Table 26). K concentration in leaves and stems decreased from 15 to 90 DAE, whereas in earheads maximum potassium concentration was recorded at 75 DAE. The applied potassium did not have any effect on Potassium concentration of leaves, stems and earheads in any of the growth stage.

4.2.13 Potassium Concentration in Whole Plant

The differences in potassium concentration (%) in whole plant were not significant both among cultivars and potash levels (Table 27).

4.2.14 Potassium Uptake by Leaves

Potassium uptake in leaves (kg ha^{-1}) (Table 28) showed that there was an increase from 15 DAE to 60 DAE and later it decreased. There was a significant

Table 26: Potassium concentration (%) in different plant parts of sorghum cultivars as influenced by potash levels during 1988 rainy season

Treatment	DAYS AFTER EMERGENCE														
	15		30		45		60			75			90		
	L	S	L	S	L	S	L	S	E	L	S	E	L	S	E
Cultivar means															
SPV-462 (C_1)	4.28	4.14	3.98	3.77	3.19	3.10	2.16	1.81	2.00	2.11	1.58	2.10	2.05	1.52	2.02
CSH - 5 (C_2)	4.11	4.04	3.93	3.77	3.42	3.22	2.14	1.81	1.98	2.17	1.57	2.09	2.10	1.53	2.01
C.D. (5%)	0.15	NS	NS	NS	0.24	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Potash levels (kg K_2O ha^{-1})															
0 (K_0)	4.18	4.06	4.04	3.78	3.54		2.15	1.80	1.96	2.14	1.55	2.10	2.09	1.51	2.10
20 (K_1)	4.20	4.12	3.81	3.69	2.89		2.11	1.81	1.98	2.10	1.54	2.11	2.03	1.49	2.05
40 (K_2)	4.14	4.05	4.00	3.83	3.28		2.15	1.80	2.01	2.23	1.61	2.03	2.14	1.54	1.96
60 (K_3)	4.30	4.12	3.98	3.78	3.53		2.19	1.83	2.04	2.10	1.61	2.14	2.05	1.55	2.04
C.D.(5%)	NS	NS	NS	NS	0.34		NS	NS	NS	NS	NS	NS	NS	NS	NS
Treatment means															
$C_1 \times K_0$	4.20	4.05	4.13	3.76	3.60		2.15	1.80	2.03	2.13	1.60	2.08	2.08	1.53	2.00
$C_1 \times K_1$	4.28	4.18	3.83	3.70	2.63		2.13	1.85	1.98	2.05	1.53	2.15	1.98	1.45	2.08
$C_1 \times K_2$	4.28	4.15	3.93	3.73	3.05		2.15	1.80	2.00	2.18	1.55	2.08	2.10	1.50	2.00
$C_1 \times K_3$	4.38	4.20	4.05	3.90	3.50		2.23	1.80	2.03	2.10	1.68	2.10	2.05	1.60	2.00
$C_2 \times K_0$	4.15	4.08	3.95	3.80	3.48		2.15	1.80	1.90	2.15	1.50	2.13	2.10	1.50	2.03
$C_2 \times K_1$	4.13	4.08	3.80	3.68	3.15		2.10	1.78	1.98	2.15	1.55	2.08	2.08	1.53	2.03
$C_2 \times K_2$	4.00	3.95	4.10	3.93	3.50		2.15	1.80	2.03	2.28	1.68	1.98	2.18	1.58	1.93
$C_2 \times K_3$	4.18	4.05	3.90		3.55		2.15	1.85	2.05	2.10	1.55	2.18	2.05	1.50	2.08
Cultivar x Potash levels C.D. (5%)	0.30	NS	NS	NS	0.49	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

N.S.: Not significant; L = Leaves; S = Stems; E = Earheads

Table 27: K-concentration of whole plant (%) of sorghum cultivars as influenced by potash levels during 1988 rainy season

Treatments	DAYS AFTER EMERGENCE					
	15	30	45	60	75	90
Cultivar means						
SPV-462 (C_1)	4.24	3.90	3.36	1.90	1.82	1.72
CSH - 5 (C_2)	4.12	3.88	3.32	1.91	2.01	1.75
C.D. (5%)	NS	NS	NS	NS	NS	NS
Potash levels (kg K_2O ha^{-1})						
0 (K_0)	4.19	3.96	3.28	1.84	1.82	1.74
20 (K_1)	4.34	3.77	3.19	2.32	1.78	1.73
40 (K_2)	4.09	3.94	3.43	2.15	1.82	1.70
60 (K_3)	4.18	3.90	3.37	2.13	1.83	1.77
C.D.(5%)	NS	NS	NS	NS	NS	NS
Treatment means						
$C_1 \times K_0$	4.22	4.02	3.17	2.58	1.88	1.74
$C_1 \times K_1$	4.27	3.78	3.23	2.31	1.77	1.71
$C_1 \times K_2$	4.26	3.85	3.48	2.08	1.79	1.65
$C_1 \times K_3$	4.26	4.03	3.41	2.09	1.85	1.77
$C_2 \times K_0$	4.12	3.90	3.38	2.45	1.75	1.73
$C_2 \times K_1$	4.41	3.76	3.16	2.33	1.77	1.74
$C_2 \times K_2$	3.98	4.03	3.38	2.24	1.85	1.75
$C_2 \times K_3$	4.14	3.81	3.36	2.17	1.81	1.76
Cultivar x Potash levels C.D. (5%)	NS	NS	NS	NS	NS	NS

N.S.: Not significant

Table 28: K-uptake in leaves (kg ha^{-1}) of sorghum cultivars as influenced by potash levels during 1988 rainy season

Treatments	DAYS AFTER EMERGENCE					
	15	30	45	60	75	90
Cultivar means						
SPV-462 (C_1)	3.09	27.79	33.45	40.38	30.25	21.58
CSH - 5 (C_2)	3.75	23.94	31.96	34.98	27.94	21.01
C.D. (5%)	0.30	2.04	2.26	1.79	1.67	NS
Potash levels (kg K_2O ha^{-1})						
0 (K_0)	2.74	21.67	19.97	26.00	22.03	17.42
20 (K_1)	3.11	24.06	25.34	33.07	26.73	19.18
40 (K_2)	3.95	30.05	44.85	46.56	37.29	26.83
60 (K_3)	3.88	27.69	40.65	45.08	30.32	21.74
C.D.(5%)	0.43	2.87	2.38	2.53	2.37	1.97
Treatment means						
$C_1 \times K_0$	2.79	22.50	19.89	26.61	23.51	17.51
$C_1 \times K_1$	3.05	26.68	26.13	33.47	28.06	18.52
$C_1 \times K_2$	3.25	31.76	46.35	52.01	38.33	27.56
$C_1 \times K_3$	3.28	30.25	41.44	49.45	31.11	22.73
$C_2 \times K_0$	2.70	20.84	20.05	25.40	20.56	17.34
$C_2 \times K_1$	3.18	21.45	24.56	32.68	25.40	19.84
$C_2 \times K_2$	4.66	28.35	43.36	41.12	36.26	26.10
$C_2 \times K_3$	4.49	25.13	39.87	40.72	29.53	20.76
Cultivar x Potash levels C.D. (5%)	0.61	4.09	3.36	3.58	3.57	2.78

N.S.: Not significant

difference among cultivars. Cv. SPV-462 was found to be superior to cv. CSH-5.

Potash levels differed significantly. Potash level at 40 kg ha^{-1} was significantly superior over control, the increase being 79 per cent at 60 DAE.

Interaction between cultivars and potash levels was also significant. Cv. SPV-462 at 40 kg K_2O ha^{-1} recorded maximum potassium uptake. In the case of cv. CSH-5 also, 40 kg K_2O ha^{-1} recorded more potassium uptake followed by other levels.

4.2.15 Potassium Uptake by Stems

Potassium uptake in stems (kg ha^{-1}) (Table 29) showed that there was increase in uptake throughout the crop growth period. Among cultivars there was no significant difference upto 30 DAE. Thereafter cv. SPV-462 was found to be significantly superior to cv. CSH-5. Among potash levels, 40 kg ha^{-1} was found to be significantly superior over other three potash levels, the increase being 27.3 per cent over control. Interaction between cultivars and potash levels was also significant. Cv. SPV-462 at 60 kg K_2O ha^{-1} recorded maximum potassium uptake. Cv. CSH-5 at 40 kg K_2O ha^{-1} recorded more potassium uptake in stems over other three levels.

Table 29: K-uptake in stems (kg ha^{-1}) of sorghum cultivars as influenced by potash levels during 1988 rainy season

Treatments	DAYS AFTER EMERGENCE					
	15	30	45	60	75	90
<u>Cultivar means</u>						
SPV-462 (C_1)	1.58	15.57	26.09	92.05	93.88	98.24
CSH - 5 (C_2)	1.48	16.49	23.55	83.49	87.49	95.24
C.D. (5%)	NS	NS	1.50	5.39	2.92	2.02
<u>Potash levels</u> (kg K_2O ha^{-1})						
0 (K_0)	1.28	13.98	15.87	65.98	77.07	83.08
20 (K_1)	1.36	14.84	19.33	80.98	86.04	95.91
40 (K_2)	1.83	19.63	33.44	103.95	102.64	105.87
60 (K_3)	1.65	15.66	30.64	100.17	96.97	102.09
C.D.(5%)	0.28	3.10	2.20	7.63	4.15	2.86
<u>Treatment means</u>						
$C_1 \times K_0$	1.56	13.68	16.25	66.48	82.15	82.64
$C_1 \times K_1$	1.44	15.35	19.21	87.41	86.35	94.89
$C_1 \times K_2$	1.82	18.36	35.80	109.01	102.59	106.03
$C_1 \times K_3$	1.50	14.89	33.12	105.30	104.43	109.40
$C_2 \times K_0$	1.01	14.29	15.49	65.48	72.00	83.53
$C_2 \times K_1$	1.28	14.34	19.45	74.55	85.74	96.93
$C_2 \times K_2$	1.84	20.90	31.08	98.89	102.70	105.72
$C_2 \times K_3$	1.80	16.43	28.17	95.05	89.51	94.78
Cultivar x Potash levels C.D. (5%)	0.40	4.36	3.11	10.80	5.87	4.03

N.S.: Not significant

4.2.16 Potassium Uptake by Earheads

Potassium uptake by earheads (kg ha^{-1}) (Table 30) showed that there was significant difference among cultivars from 75 DAE. Cv. SPV-462 was found to be superior to cv. CSH-5.

The differences in potash levels were also significant. Potash level at 40 kg ha^{-1} was found to be significantly superior, the increase being 24.36 per cent over control.

Interaction between cultivars and potash levels was also significant. Cv. SPV-462 at 40 kg K_2O ha^{-1} recorded maximum potassium uptake by earheads, whereas cv. CSH-5 at 60 kg K_2O ha^{-1} recorded more potasium uptake over other potash levels.

4.2.17 Potassium Uptake by Whole Plant

Potassium uptake by whole plant (kg ha^{-1}) (Table 34 & Fig.7) increased from 15 DAE to 90 DAE. Cultivars differed significantly at 60 and 75 DAE. Cv. SPV-462 was superior to cv. CSH-5. Potash levels differed significantly as to the potassium uptake by the whole plant. Potash level at 40 kg ha^{-1} recorded more potassium uptake over control, the increase being 25.7 per cent. Interaction between cultivars and potash levels was also significant. Cv. CSH-5 at 40 kg K_2O ha^{-1} recorded maxi-

Table 30: K-uptake by earheads (kg ha^{-1}) of sorghum cultivars as influenced by potash levels during 1988 rainy season

Treatments	DAYS AFTER EMERGENCE		
	60	75	90
Cultivar means			
SPV-462 (C_1)	26.63	62.31	79.35
CSH - 5 (C_2)	25.12	56.63	76.00
C.D. (5%)	NS	3.44	1.55
Potash levels ($kg\ K_2O\ ha^{-1}$)			
0 (K_0)	17.27	50.79	67.27
20 (K_1)	26.73	58.35	79.95
40 (K_2)	30.53	64.13	83.66
60 (K_3)	29.58	64.40	79.68
C.D.(5%)	2.39	4.85	2.18
Treatment means			
$C_1 \times K_0$	18.27	54.60	70.50
$C_1 \times K_1$	25.99	61.68	82.68
$C_1 \times K_2$	32.25	69.03	87.75
$C_1 \times K_3$	30.45	64.18	76.50
$C_2 \times K_0$	16.39	47.13	64.33
$C_2 \times K_1$	27.47	55.38	77.65
$C_2 \times K_2$	28.93	59.40	79.97
$C_2 \times K_3$	28.70	64.58	82.94
Cultivar x Potash levels C.D. (5%)	3.39	6.87	3.09

N.S.: Not significant

Table 31: K-uptake by whole plant (kg ha^{-1}) of sorghum cultivars as influenced by potash levels during 1988 rainy season

Treatments	DAYS AFTER EMERGENCE					
	15	30	45	60	75	90
Cultivar means						
SPV-462 (C_1)	4.67	43.37	59.55	159.26	186.48	196.41
CSH - 5 (C_2)	5.24	40.43	55.51	144.00	171.91	192.29
C.D. (5%)	0.46	NS	NS	12.00	4.00	NS
Potash levels (kg K_2O ha^{-1})						
0 (K_0)	4.03	35.65	35.84	109.68	149.85	167.84
20 (K_1)	4.47	38.91	44.67	140.71	171.24	195.06
40 (K_2)	5.78	49.68	78.29	181.08	204.00	211.03
60 (K_3)	5.53	43.35	71.30	175.05	191.69	203.46
C.D.(5%)	0.68	7.10	8.00	17.00	5.00	16.00
Treatment means						
$C_1 \times K_0$	4.35	36.18	36.14	111.32	160.13	170.65
$C_1 \times K_1$	4.49	42.03	45.34	146.80	176.09	195.89
$C_1 \times K_2$	5.07	50.12	82.15	193.3	209.79	210.47
$C_1 \times K_3$	4.78	45.14	74.56	185.63	199.91	208.63
$C_2 \times K_0$	3.71	35.13	35.54	108.04	139.58	165.04
$C_2 \times K_1$	4.46	35.79	44.01	134.63	166.39	194.23
$C_2 \times K_2$	6.50	49.25	74.44	168.87	198.21	211.59
$C_2 \times K_3$	6.29	41.56	68.04	164.47	183.47	198.30
Cultivar x Potash levels C.D. (5%)	0.97	10.10	11.30	23.00	7.00	23.00

N.S.: Not significant

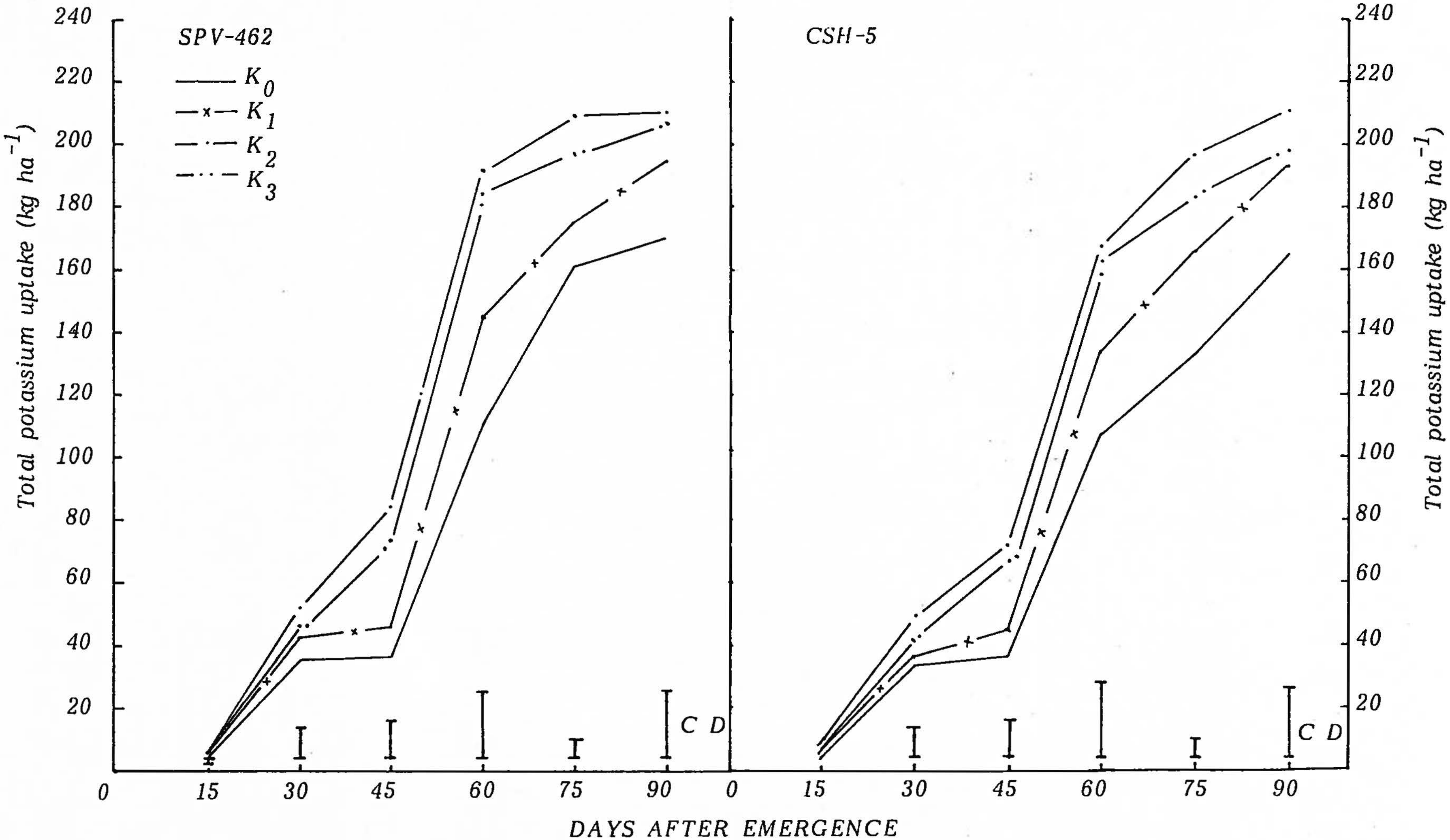


Fig. **7** *Total potassium uptake (kg ha^{-1}) in sorghum as influenced by potash levels* mum potassium uptake while in the case of cv. SPV-462, the same potash level recorded higher potassium uptake by the whole plant.

4.2.18 N,P,K and Protein Content in Grains

No significant differences in N,P,K and protein content of grain (%) were noticed (Table 32). But potash application at 40 kg ha^{-1} slightly improved N percentage and consequently grain protein content.

4.2.19 Epicuticular Wax

The data on epicuticular wax (mg m^{-2})(Table 32) were found to be not significant among cultivars and among potash levels also. There was no effect of applied potassium on wax content.

4.2.20 Nitrate Reductase Activity

Nitrate reductase activity (NRA) was recorded 3 times during the growth of sorghum (Table 33). It was found to be not significant among cultivars and also potash levels. NRA recorded a decreasing trend from 35th day to 85 DAE.

4.2.21 Total Chlorophyll

Total chlorophyll was recorded at 45, 60 and 75 DAE (Table 34). At 45 DAE chlorophyll content was maximum

Table 32: N, P, K, Protein content of grain (%) and Epicuticular wax in leaves (mg m^{-2}) of sorghum cultivars as influenced by potash levels during 1988 rainy season

Treatments	N (%)	P (%)	K (%)	Protein content of grains (%)	Epicuticular wax (mg m^{-2})
Cultivar means					
SPV-462 (C_1)	1.62	0.32	0.41	10.12	119
CSH - 5 (C_2)	1.62	0.32	0.41	10.12	121
C.D. (5%)	NS	NS	NS	NS	NS
Potash levels (kg K_2O ha^{-1})					
0 (K_0)	1.61	0.32	0.42	10.06	120
20 (K_1)	1.62	0.32	0.42	10.12	119
40 (K_2)	1.64	0.32	0.42	10.25	118
60 (K_3)	1.61	0.31	0.41	10.06	123
C.D.(5%)	NS	NS	NS	NS	NS
Treatment means					
$C_1 \times K_0$	1.62	0.32	0.42	10.12	117
$C_1 \times K_1$	1.63	0.32	0.41	10.19	115
$C_1 \times K_2$	1.63	0.32	0.41	10.19	116
$C_1 \times K_3$	1.62	0.32	0.41	10.12	127
$C_2 \times K_0$	1.60	0.32	0.42	10.00	122
$C_2 \times K_1$	1.61	0.32	0.42	10.06	123
$C_2 \times K_2$	1.65	0.32	0.42	10.31	120
$C_2 \times K_3$	1.62	0.32	0.41	10.12	120
Cultivar x Potash levels C.D. (5%)	NS	NS	NS	NS	NS

N.S.: Not significant

Table 33: NR activity (μ moles g^{-1} FW hr^{-1}) of sorghum cultivars as influenced by potash levels during 1988 rainy season

Treatments	DAYS AFTER EMERGENCE		
	35	65	85
Cultivar means			
SPV-462 (C_1)	0.77	0.51	0.47
CSH - 5 (C_2)	0.75	0.45	0.42
C.D. (5%)	NS	NS	NS
Potash levels ($kg\ K_2O\ ha^{-1}$)			
0 (K_0)	0.74	0.46	0.44
20 (K_1)	0.76	0.50	0.44
40 (K_2)	0.76	0.47	0.44
60 (K_3)	0.77	0.49	0.46
C.D.(5%)	NS	NS	NS
Treatment means			
$C_1 \times K_0$	0.71	0.48	0.48
$C_1 \times K_1$	0.80	0.55	0.48
$C_1 \times K_2$	0.81	0.52	0.48
$C_1 \times K_3$	0.76	0.49	0.45
$C_2 \times K_0$	0.77	0.45	0.40
$C_2 \times K_1$	0.72	0.46	0.41
$C_2 \times K_2$	0.72	0.43	0.40
$C_2 \times K_3$	0.78	0.49	0.46
Cultivar x Potash levels C.D. (5%)	NS	NS	NS

N.S.: Not significant

Table 34: Total chlorophyll (mg g^{-1} FW) of sorghum cultivars as influenced by potash levels during 1988 rainy season

Treatments	DAYS AFTER EMERGENCE		
	45	60	75
Cultivar means			
SPV-462 (C_1)	1.95	1.74	1.37
CSH - 5 (C_2)	2.72	2.36	1.84
C.D. (5%)	0.31	0.24	0.21
Potash levels ($kg\ K_2O\ ha^{-1}$)			
0 (K_0)	1.88	1.66	1.42
20 (K_1)	2.23	1.92	1.47
40 (K_2)	2.73	2.32	1.72
60 (K_3)	2.51	2.31	1.80
C.D.(5%)	0.38	0.31	0.29
Treatment means			
$C_1 \times K_0$	1.44	1.23	1.08
$C_1 \times K_1$	1.93	1.66	1.24
$C_1 \times K_2$	2.34	2.12	1.63
$C_1 \times K_3$	2.08	1.95	1.64
$C_2 \times K_0$	2.31	2.08	1.75
$C_2 \times K_1$	2.52	2.17	1.70
$C_2 \times K_2$	3.11	2.52	1.95
$C_2 \times K_3$	2.94	2.66	1.95
Cultivar x Potash levels C.D. (5%)	0.49	0.81	0.60

N.S.: Not significant

and then onwards it declined. Cultivars differed significantly. Cv. CSH-5 was significantly superior over cv. SPV-462. Among potash levels, there were significant differences. At 45 DAE 40 kg K_2O ha^{-1} was found to be significantly superior over 0 and 20 kg K_2O ha^{-1}, the increase being 45 per cent over control.

Interaction between cultivars and potash levels was also significant. Cv. CSH-5 at 40 kg K_2O ha^{-1} recorded maximum chlorophyll. Cv. SPV-462 recorded more chlorophyll over other three levels.

4.3 YIELD AND YIELD COMPONENTS

4.3.1 Number of Primary and Secondary Rachii $Earhead^{-1}$

The data on primary and secondary rachii $earhead^{-1}$ were furnished in (Table 35).

The differences in the number of primary rachii per earhead were not significant between the cultivars, whereas significant differences were obtained with the number of secondary rachii per earhead.

Potash levels also differed significantly for the above two parameters. Potash level at 40 kg ha^{-1} produced more number of primary and secondary rachii $earhead^{-1}$, the percentage increase over control was 22.7 and 20.4 for primary and secondary rachii respectively.

Interaction between cultivars and potash levels was also significant. Cv. SPV-462 at 40 kg K_2O ha^{-1} recorded maximum values in both the parameters. In the case of cv. CSH-5 also, highest values were obtained at the same potash level.

4.3.2 Number of Grains $Panicle^{-1}$

The data recorded on the number of grains per panicle (Table 35 & Plate 1) revealed that there was significant difference between cultivars. Cv. SPV-462 had more number of grains in its earhead than in cv. CSH-5. Among potash levels, 40 and 60 kg ha^{-1} were on par but significantly superior to 0 and 20 kg ha^{-1}.

There was significant difference in potash and cultivar interaction also. Cv. SPV-462 at 40 kg K_2O ha^{-1} had maximum number of grains $panicle^{-1}$ and cv. CSH-5 also maintained more number of grains $panicle^{-1}$ at the same potash level.

4.3.3 Seed Yield

The data on yield and yield components were furnished in Table 35 and Fig. 8.

The seed yield differences among the cultivars were not significant but the differences among the potash levels were found to be significant. Potash levels at

Table 35: Yield and yield components in sorghum cultivars as influenced by potash levels during 1988 rainy season

Treatment	Seed yield (kg ha^{-1})	1000 grain weight (g)	H.I. (%)	No. of primary rachii $earhead^{-1}$	No. of secondary rachii $earhead^{-1}$	No. of grains $panicle^{-1}$
<u>Cultivar means</u>						
SPV-462 (C_1)	5151	21.6	27.8	52.0	314	1730
CSH - 5 (C_2)	5051	21.8	34.0	52.3	293	1602
C.D. (5%)	NS	NS	2.9	NS	6	33
<u>Potash levels</u> (kg K_2O ha^{-1})						
0 (K_0)	4383	18.8	29.1	46.1	274	1505
20 (K_1)	4912	22.1	30.4	50.6	289	1589
40 (K_2)	5692	23.2	31.9	56.6	330	1810
60 (K_3)	5419	22.6	32.3	55.2	320	1757
C.D.(5%)	591	0.8	NS	1.6	8	55
<u>Treatment means</u>						
$C_1 \times K_0$	4257	18.6	26.2	45.3	268	1480
$C_1 \times K_1$	4915	21.8	27.0	48.9	296	1628
$C_1 \times K_2$	5951	23.4	28.7	58.1	351	1930
$C_1 \times K_3$	5481	22.7	29.2	55.8	342	1881
$C_2 \times K_0$	4510	19.1	32.0	47.0	280	1529
$C_2 \times K_1$	4907	22.5	33.7	52.3	284	1551
$C_2 \times K_2$	5432	23.0	35.1	55.1	310	1693
$C_2 \times K_3$	5357	22.6	35.3	54.6	299	1633
<u>Cultivar x Potash levels</u> C.D. (5%)	836	1.1	5.8	2.3	11	71

N.S.: Not significant

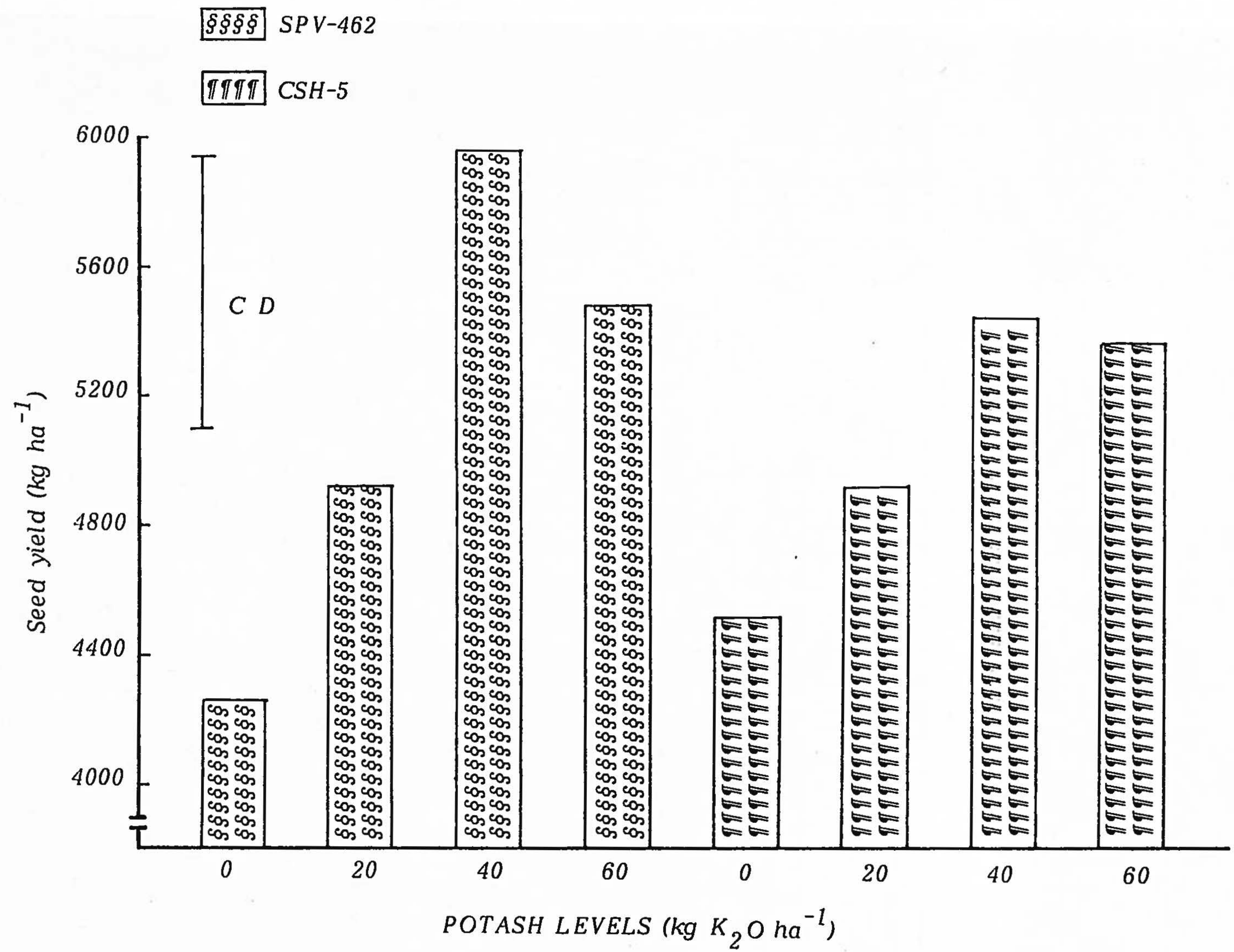
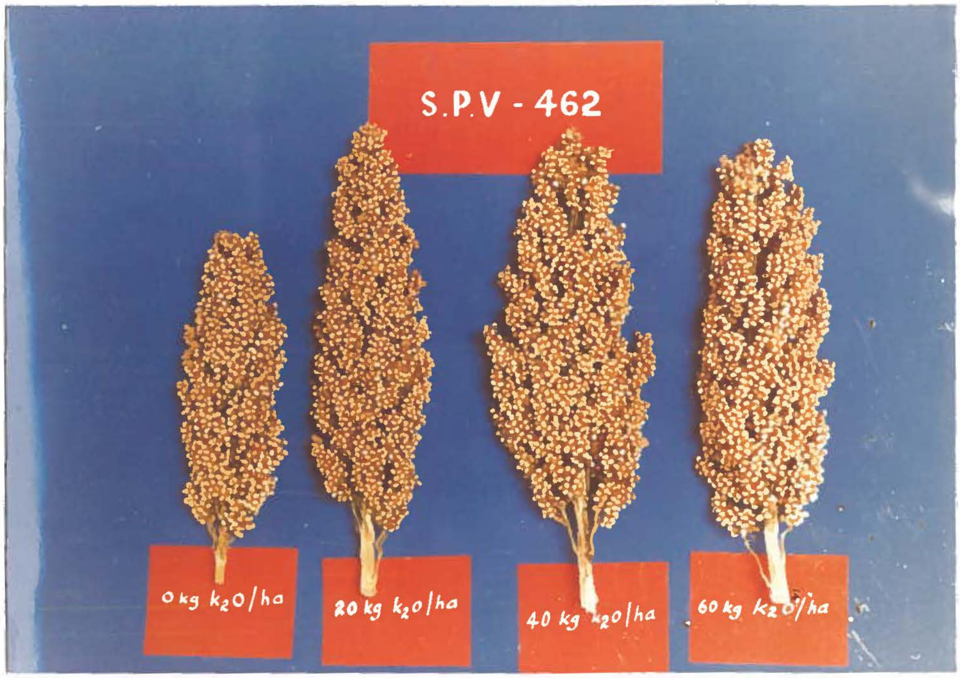


Fig. 8 : Seed yield in sorghum cultivars as influenced by potash levels

Plate 1

Number of grains per earhead of sorghum cultivars as influenced by potash levels


S.P.V - 462
0 kg K_2O/ha
20 kg K_2O/ha
40 kg K_2O/ha
60 kg K_2O/ha


C.S.H - 5
0 kg K_2O/ha
20 kg K_2O/ha
40 kg K_2O/ha
60 kg K_2O/ha

40 and 60 kg ha^{-1} were on par but significantly superior to 0 and 20 kg K_2O ha^{-1}. Potash level at 40 kg ha^{-1} recorded maximum yield of 5692 kg ha^{-1} followed by 60 kg ha^{-1} (5419 kg ha^{-1}).

Interaction between cultivars and potash levels was also significant. Cv. SPV-462 at 40 kg K_2O ha^{-1} recorded maximum seed yield (5951 kg ha^{-1}). In respect of cv. CSH-5 also, more yield was obtained at the same potash level (5432 kg ha^{-1}).

4.3.4 1000 Grain Weight

The differences in 1000 grain weight (g) were not significant among the cultivars, but the potash levels significantly differed (Table 35 and Fig.9). Potash level at 40 kg ha^{-1} was significantly superior to the rest of three levels, the increase being 19 per cent over control.

The interaction between cultivars and potash levels was also significant. Cv. SPV-462 at 40 kg K_2O ha^{-1} recorded maximum 1000 grain weight. In the case of cv. CSH-5 also, higher 1000 grain weight was recorded at the same potash level.

4.3.5 Harvest Index

Harvest Index (HI) (%) differed significantly among cultivars (Table 35). Cv. CSH-5 was found to be superior

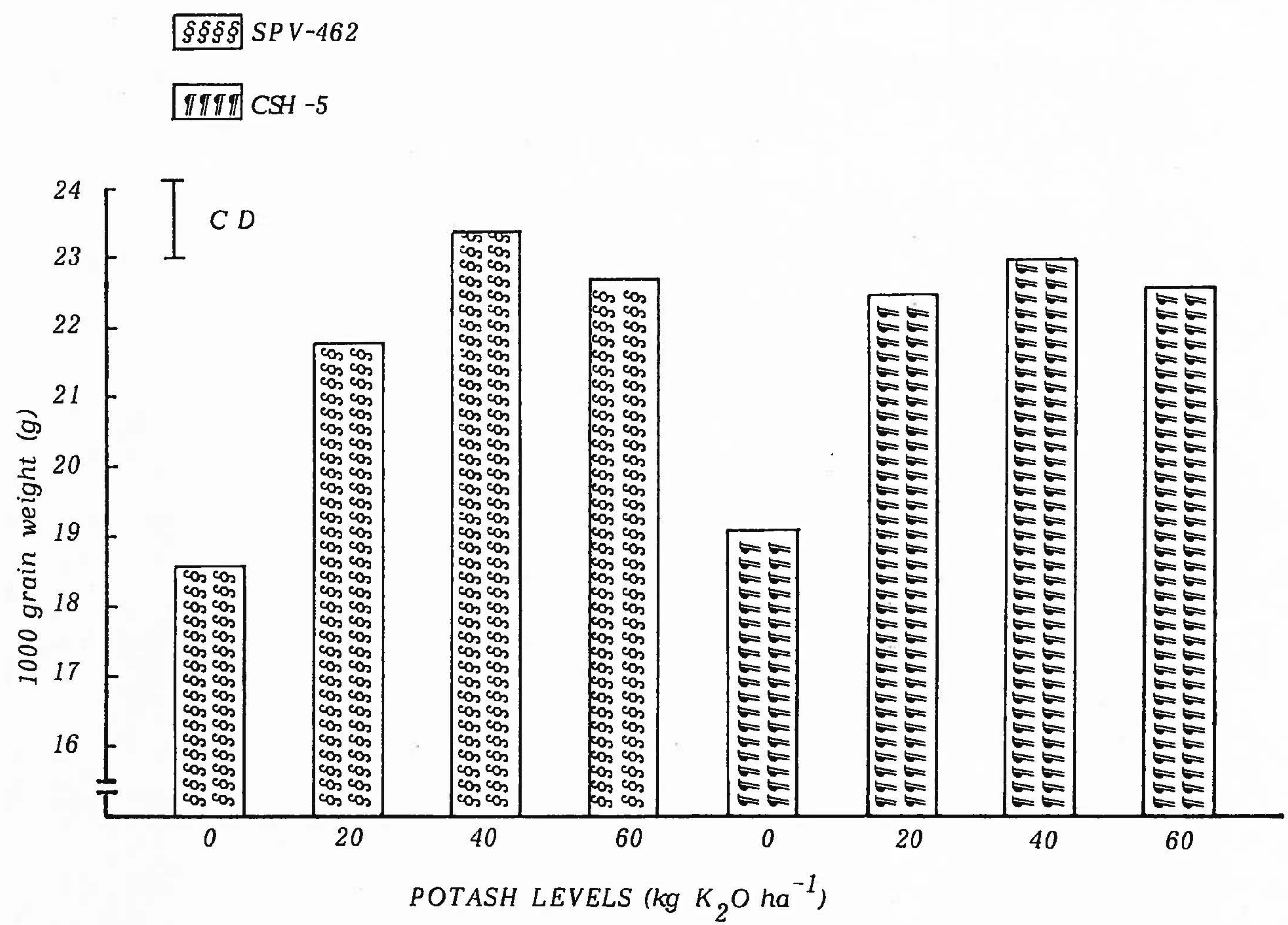


Fig. 9: 1000 grain weight in sorghum cultivars as influenced by potash levels

to cv. SPV-462. There was no significant difference among potash levels in respect of HI. But in general it was observed that higher doses of potash improved HI. Interaction among cultivaers and potash levels was significant. Cv. CSH-5 at 60 kg K_2O ha^{-1} recorded maximum HI while in the case of cv. SPV-462 also, HI values were more at the same potash level.

4.4 CORRELATION MATRIX

The correlation matrix pertaining to yield and yield components was furnished in Table 36 for CSH-5 and in Table 37 for SPV-462. Grain yield was positively correlated to LAI (0.987*), H.I (0.989*), number of primary rachii (0.972*), CGR (0.99**), and NAR (0.999**) for Cv. CSH-5. In the case of cv. SPV-462, the yield was positively correlated to LAI (0.953), 1000 grain weight (0.954*), number of primary rachii (0.985*) and CGR at 60 DAE (0.984*).

Table 36 : Correlation matrix of sorghum cultivar CSH-5

	LAI 60 DAE	Total Dry matter (9 m^{-2})	Total K-uptake (kg ha^{-1})	1000 grain weight (g)	H.I. (%)	No. of primary rachii	CGR (g m^{-2} day^{-1}) 45 DAE	CGR (g m^{-2} day^{-1}) 60 DAE	RGR (g m^{-2} day^{-1}) 45 DAE	NAR (g g^{-1} day^{-1}) 45 DAE	Yield (kg ha^{-1})
LAI 60 DAE	1.000										
Total Dry matter (g m^{-2})	0.951	1.000									
Total K-uptake (kg ha^{-1})	0.965*	0.999**	1.000								
1000 grain weight (g)	0.959*	0.960*	0.964*	1.000							
H.I. (%)	0.989*	0.903	0.924	0.910	1.000						
No. of primary rachii	0.999**	0.961*	0.975*	0.968*	0.983*	1.000					
CGR (g m^{-2} day^{-1}) 45 DAE	0.956*	0.884	0.904	0.839	0.979*	0.948	1.000				
CGR (g m^{-2} day^{-1}) 60 DAE	0.985*	0.961*	0.973*	0.941	0.986*	0.994**	0.973*	1.000			
RGR (g g^{-1} day^{-1}) 45 DAE	0.910	0.742	0.773	0.835	0.941	0.898	0.876	0.878	1.000		
NAR (g m^{-2} day^{-1}) 45 DAE	0.974*	0.906	0.925	0.873	0.990**	0.968*	0.998**	0.985*	0.892	1.000	
Yield (kg ha^{-1})	0.978*	0.919	0.937	0.884	0.989*	0.972*	0.886	0.990**	0.883	0.999**	1.000

* r 5% = 0.950 ** r 1% = 0.990

Table 37: Correlation matrix of sorghum cultivar SPV-462

	LAI 60 DAE	Total Dry matter (g m-2)	Total K-uptake (kg ha^{-1})	1000 grain weight (g)	H.I. (%)	No. of primary rachii	CGR (g m^{-2} day^{-1}) 45 DAE	CGR (g m^{-2} day^{-1}) 60 DAE	RGR (g g^{-1} day^{-1}) 45 DAE	NAR (g m^{-2} day^{-1}) 45 DAE	Yield (kg ha^{-1})
LAI	1.000										
Total Drymatter (g m^{-2})	0.932	1.000									
Total K-uptake (kg ha^{-1})	0.938	0.956*	1.000								
1000 grain weight (g)	0.922	0.979*	0.993**	1.000							
H.I. (%)	0.945	0.816	0.920	0.870	1.000						
No. of primary rachii	0.999**	0.920	0.936	0.915	0.954*	1.000					
45 DAE CGR (g m^{-2} day^{-1})	0.956*	0.786	0.850	0.801	0.972*	0.965*	1.000				
60 DAE CGR (g m^{-2} day^{-1})	0.990**	0.953*	0.978*	0.964*	0.952*	0.989*	0.929	1.000			
45 DAE RGR (g g^{-1} day^{-1})	0.907	0.701	0.799	0.736	0.966*	0.921	0.990**	0.881	1.000		
45 DAE NAR (g g^{-1} day^{-1})	0.936	0.745	0.812	0.758	0.959*	0.947	0.998**	0.902	0.994**	1.000	
Yield (kg ha^{-1})	0.990**	0.972*	0.955*	0.954*	0.906	0.985*	0.905	0.989*	0.841	0.878	1.000

*r 5% = 0.950 **r 1% = 0.990

DISCUSSION

CHAPTER V

DISCUSSION

In the present study an attempt was made to know the response of sorghum cultivars to the added potassium under rainfed conditions. Growth of the plant can be measured in many ways and the simplest way is by recording plant height. Plant height increased gradually from seedling stage upto grain filling. Potash levels significantly influenced the plant height (Fig.3). The maximum plant height of 196.6 cm was recorded with 40 kg K_2O ha^{-1} followed by 192.3 cm recorded with 60 kg K_{2O} ha^{-1} as compared to control, which recorded 173.9 cm of height. The increase in height was due to increased internodal elongation. Generally potassium deficiency causes decrease in height due to increased ABA and reduced cytokinins in the plant. It was supported by Mizra (1980). The reduction in height due to potassium deficiency was also reported by Pitman (1972), Sader and Sauza (1982), Muramkar and Karadge (1982).

The leaf number is the representation of photosynthetic surface area and is an important character for productivity. The leaf number gradually increased upto 60 DAE and declined later due to leaf senescence. Applied potassium did not have any influence on the total number of leaves. The significant difference found in the total number of leaves upto 45 DAE was due to faster growth of plants with added potash. Photosynthetic efficiency of a variety not only depends on the number of leaves produced but also on the leaf area and leaf area index (LAI). An optimum LAI is required. Higher LAI may lead to mutual shading while lower LAI may be insufficient to cover the land area, which results in poor light interception. Leaf area and LAI increased gradually from seedling stage and recorded a maximum value by 60 DAE (Fig. 5). The decrease thereafter was due to senescence. Increase in the level of applied potassium significantly increased leaf area and LAI upto 40 kg K_2O ha^{-1}. At that level, maximum leaf area of 392 dm^2 m^{-2} and LAI of 3.92 were recorded. Such promotive effect of applied potassium was reported by Forster (1976).

Early maturity is an important mechanism in escaping the effect of drought. Potassium had a positive influence on time taken for maturity. In crops like soybean and maize, potassium hastened the maturity (Darst, 1980). Similar results were obtained in the present investigation also. Potash at 40 and 60 kg K_2O ha^{-1} resulted in early maturity.

Accelerated leaf senescence reduces photosynthetic area and duration. K^+ delays senescence and leaf firing and increases sink activity. K^+ level at 40 kg ha^{-1} resulted in less leaf firing. These results were supported by Haeder (1980).

Determination of phytomass production is the most accurate and precise method of expressing growth. Potassium had direct influence on plant's meristamatic activity. Dry matter response to increasing levels of exchangeable potassium in the soil in pot studies with increasing levels of soil moisture stress had been reported by Mengel and Braunschweig (1972). Dry weight of leaves increased upto 60 DAE while stem dry weight and total dry matter increased upto harvest (Fig.4). Maximum plant phytomass was recorded with 40 kg K_2O ha^{-1} which might be due to cummulative effect of characters like plant height and leaf area which increased vegetative growth and photosynthetic activity over control. Similar results were recorded in sorghum by Theodore et al (1970); Ekpete (1972); Gill and Abichandani (1976); Murumkar and Karadge (1982); Rosolem (1983) and Ogunlela (1988).

Yield gets influenced by dry matter partitioning. Sink activity and duration are enhanced by K^+ status. K^+ is also known to influence assimilate translocation. Allocation of a high proportion of assimilates to new photosynthetic tissue maximises crop growth. Reserve assimilate is an important source for grain growth. K^+ influences assimilate distribution, sink capacity, sink filling and remobilisation of reserve assimilates in relation to various environmental factors (Haeder, 1980; Fischer and Turner, 1978). Differences were not found in dry matter partitioning among various potash levels which might be due to high soil potassium status.

Pitman (1971) observed a good correlation between transport of K^+ from root to shoot and RGR in barley. Till 30 DAE, no significant difference was noticed in RGR. At 30 DAE, when the plants were well established, a second dose of potash was applied. That added potash might have increased the available K^+ near the root zone, which was usually 6 per cent of the total K^+ available as observed by Drew and Nye (1969). It was also found that the added K^+ ions were mostly held in the soil as an exchangeable form and the fixation capacity of red soil was low to added potash (Tandon and Sekhon, 1988). Because of the sudden increase in the availability of K^+, there was an increased uptake of K^+ at the crucial panicle initiation stage as it was found that about 60 per cent of the total K^+ uptake in sorghum was completed before heading (Roy and Wright, 1974). This has resulted in a significant difference at 45 DAE in RGR. Potash at 40 and 60 kg ha^{-1} recorded maximum RGR which helped the plants to accelerate growth. At 75 and 90

DAE, potash at 0 and 20 kg ha^{-1} showed higher RGR when compared to 40 and 60 kg K_2O ha^{-1} which might be due to early maturation of the latter treatments. Similar trend was noticed with CGR also (Fig.6). Because of the increase in RGR at 45 DAE, the CGR values at 40 kg K_2O ha^{-1} were maintained highest upto 60 DAE. The applied potash at 30 DAE had a very good influence on NAR also at 45 DAE. Olekneskо (1988) also observed beneficial effect of applied K^+ on NAR. But at 75 and 90 DAE, potash at 0 and 20 kg ha^{-1} had significantly higher values of NAR when compared to 40 and 60 kg ha^{-1}. The reasons for this kind of response might be due to the early maturation of the plants supplied with higher potash i.e. 40 and 60 kg ha^{-1}.

Epicuticular wax plays an important role and serves as a boundary layer between plant and environment. It also conserves water, protect leaves from injury due to wind and radiation and physical abrasion or pathogen attack (Martin and Jupiner, 1970). In the present investigation, the potash levels did not show any influence on epicuticular wax content.

K^+ is involved in metabolic reactions including those of energy (ATP) synthesis and energy transfer. Metabolic energy is generated by the chloroplasts in the process of photophosphorylation. Light driven electron transport releases protons from the stroma into the inner space of the thylakoid compartment of the chloroplasts (Trebst, 1974). Cations especially K^+ are moved out into the stroma of the chloroplast in exchange for inward movement of protons. According to Lauchli and Pfluger (1978), K^+ in a concentration range of about 100 mM seems to be necessary for high efficiency in energy transfer. The deficiency of potassium causes reduced chlorophyll content in the leaves, which contribute to impairment of photosynthetic machinery. Chlorophyll content in sorghum cultivars increased at higher potassium levels which lead to higher photosynthetic efficiency in terms of NAR etc. Similar findings were reported by Stamp (1978), Murumkar and Karadge (1982) and Oleksenko (1988).

Potassium application did not show any significant difference in Nitrate Reductase Activity (NRA) in both the cultivars. But many authors reported that potash had a positive influence on NRA (Minotti et al 1968; Shaner and Boyer 1976; Dale and Neal 1978; and Blevins et al 1978). The results obtained in the present investigation might be attributed to high potassium status of the soil.

Nitrogen, phosphorus and potassium concentrations in different plant parts and whole plant did not differ but their uptake differed significantly (Fig.7). Munson (1982) found that when crop yields were higher or hybrids were introduced with adequate N and P application, the more rapid growth markedly increased the rate of potassium uptake and the potential for response to applied potassium. Uptake of N, P and K by the whole plant was highest at 40 kg K_2O ha^{-1}. Grain yield was correlated to the nutrient uptake. Increased uptake of nutrients by sorghum cultivars with the potassium application was reported by Loetsch (1971), Roy and Wright (1974), Murumkar and Karadge (1982), Singh and Ghosh (1984), Lasztity (1984), Krishnaswamy (1986) and Ogunlela (1988).

Depressed protein synthesis possibly affect the total nitrogen turn over. It is known that the K^+ ion plays an essential role in protein synthesis. The higher K^+ supply increased the content of crude protein in the grain. But in the present investigation, applied potassium did not show any difference in protein content of the grain. Koch and Mengel (1977) found that K^+ had a positive effect on protein content. But in contrast Hsiao et al. (1970) and Theodone et al. (1970) found that grain protein was higher in K^+ deficient plants.

Application of potassium to sorghum was found to be beneficial to increase grain yield (Fig. 8). Significant increase in grain yield was recorded with the application of 40 and 60 kg K_2O ha^{-1} and the yield increase was about 30 per cent over control (0 kg K_2O ha^{-1}). This increase in yield was due to some of the yield attributing characters such as increased number of primary and secondary rachii per earhead, number of grains per erhead (Plate 1), 1000 grain weight (Fig.9), LAI, uptake of N, P and K and improved chlorphyll content. The increase in yield was reported in "kharif" sorghum with 30 kg K_20 ha^{-1} in 697 trials conducted in Andhra Pradesh, Madhya Pradesh and Maharashtra (Tandon and Sekhan, 1988).

Yield increase due to potassium application in sorghum crop was also reported by several workers such as Faisal (1971), Shekhawat et al. (1972), Hariprakash Rao (1978), Nagre and Bathkal (1978), and Nagre (1982). Gill and Abichandani (1976) reported high potassium levels recorded highest 1000 grain weight. In grain crops the number of filled ears per unit area, number of grains per earhead and the weight of each grain can be improved by K^+ nutrition. Panda (1984) observed that potash absorbed upto maximum tillering, increased both the number of panicles and grain weight, and K^+ absorbed after panicle initiation had improved grain weight in sorghum. In the present investigation, grain yield was positively correlated to LAI (0.978*), H.I. (0.989*), number of primary rachii (0.972*), CGR (0.99**), and NAR (0.999**) for cv. CSH-5. For cv. SPV-462, the yield was positively correlated to LAI (0.953*), 1000 grain weight (0.954*), number of primary rachii (0.985*) and CGR at 60 DAE (0.984*).

Harvest Index (HI) reveals the efficiency of translocation of photosynthates to economic parts. HI in sorghum was positively correlated to grain yield and negatively correlated to plant height. Potassium had no influence on harvest index in the present study.

From the results of this investigation it can be concluded that applied potassium had beneficial effect on sorghum growth and yield. Potassium improved various characters such as plant height, leaf area, early maturity, phytomass production, and biochemical parameters like chlorophyll, protein, N, P and K uptake and thereby improved the yield. But the beneficial effect was seen upto 40 kg K_2O ha^{-1} only. Later there was no significant increase. The increase in yield due to higher N, P and K uptake can also be explained from the chemical composition of the soil before and after the experiment.

The two sorghum cultivars differed significantly for many of the characters. Cv. SPV-462 responded more than cv. CSH-5 to the potash application. But there were no significant differences in yield. Cv. CSH-5 responded better for Harvest Index.

About the interaction, there were significant differences between cultivars and potash levels. Cv. SPV-462 at 40 kg K_2O ha^{-1} was found superior in many characters whereas cv. CSH-5 at 40 kg K_2O ha^{-1} recorded high values for many characters over other three levels of potash.

SUMMARY

CHAPTER VI

S U M M A R Y

The present investigation was aimed to study the response of sorghum cultivars to potash application and to fix optimum dose of potash for sorghum under rainfed conditions. The experiment was conducted with two sorghum cultivars viz., SPV-462 and CSH-5 and with four potash levels 0, 20, 40 and 60 kg K_2O ha^{-1} at Student's Farm, College of Agriculture, Rajendranagar, Hyderabad during 1988 (June-October) rainy season.

The growth parameters like plant height, leaf number, leaf area index, dry matter production and dry matter partitioning were improved by potassium application. Highest reading was recorded with 40 kg K_2O ha^{-1}. Potassium also improved nutrient uptake by the sorghum cultivars which was directly related to the grain yield. Potash at 40 kg ha^{-1} recorded highest nitrogen, phosphorus and potash uptake. Chlorophyll content was also increased by the potash application.

Growth analysis showed that potash at 40 kg ha^{-1} increased crop growth rate (CGR) and net assimilation rate (NAR). Application of potassium to sorghum was found to be helpful in respect of grain yield also. Significant increase in grain yield was recorded with the application of 40 and 60 kg K_2O ha^{-1} which were on par. The yield increase was about 30 per cent at 40 kg K_2O ha^{-1} over control. This increase in yield was due to some of yield attributing characters like increased number of primary and secondary rachii per earhead, number of grains per earhead, 1000 grain weight, LAI, CGR, NAR, uptake of N, P and K and improved chlorophyll content.

In the present investigation, grain yield was positively correlated to LAI (0.978*), H.I (0.989*), number of primary rachii (0.972*), CGR (0.990**) and NAR (0.999**) for cv. CSH-5. In the case of cv. SPV-462, the yield was positively correlated to LAI (0.953*), 1000 grain weight (0.954*), number of primary rachii (0.985*) and CGR (0.984*).

From the above it can be concluded that applied potassium had beneficial effect on sorghum growth and yield. The yield of grain crops depends mainly on the grain weight and number of grains per earhead. These can be improved by potassium application.

Among the two cultivars, SPV-462 was found to be superior for many of the parameters. But cv. CSH-5, a recommended hybrid, showed highest H.I., which is directly correlated to the grain yield and can be recommended.

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*Original not seen

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