EFFECT OF POTASSIUM ON SOIL FERTILITY, NUTRIENT UPTAKE, YIELD AND QUALITY OF PEARL MILLET IN INCEPTISOL

THESIS

Submitted to
Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola
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DECLARATION OF STUDENT

I hereby declare that the experimental work and its interpretation of the Thesis entitled **"EFFECT OF POTASSIUM ON SOIL FERTILITY, NUTRIENT UPTAKE, YIELD AND QUALITY OF PEARL MILLET"** IN INCEPTISOL or part there of has neither been submitted for any other degree or diploma of any university, nor the data have been derived from any thesis / publication of any university or scientific organization. The source of materials used and all assistance received during the course of investigation have been duly acknowledged.

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CERTIFICATE

This is to certify that the thesis entitled **"EFFECT OF POTASSIUM ON SOIL FERTILITY, NUTRIENT UPTAKE, YIELD AND QUALITY OF PEARL MILLET"** IN INCEPTISOL submitted in partial fulfillment of the requirement for the degree of **"Master of Science in Agriculture (Soil Science And Agricultural Chemistry)"** of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola is a record of bonafide research work carried out by **Deshmukh Aniket Rajendra** under my guidance and supervision.

The subject of the thesis has been approved by the Student's Advisory Committee.

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THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE INCLUDING EXTERNAL EXAMINER (AFTER VIVA-VOCE)

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(A) **List of Table**

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(C) List of Abbreviations

@	-	at the rate
A	-	Actual
B:C ratio	-	Benefit cost ratio
BSH	-	Bright sunshine hours
CC	-	Cubic centimeter
CD	-	Critical difference
CGR	-	Crop growth rate
cm	-	centimeter
cm^2	-	Centimeter square
DAS	-	Days after sowing
^0C	-	Degree Celsius
EC	-	Electrical conductivity
et al.	-	et alia (and others)
etc.	-	etcetera
Fig.	-	Figure
GM	-	Gross mean
GMR	-	Gross monetary return
ha	-	hectare
i.e.	-	that is
K	-	Potassium
kg	-	Kilogram
LAI	-	Leaf area index
m	-	Metre
m^2	-	Metre square
mm	-	Millimetre
MT	-	Metric tonnes
MW	-	Meteorological week
N	-	Nitrogen
NMR	-	Net monetary return
NS	-	Non significant
P	-	Phosphorus
%	-	Per cent

/	-	per
q	-	Quintal
RDF	-	Recommended dose of fertilizer
RF	-	Rainfall
RGR	-	Relative growth rate
RH	-	Relative humidity
Rs.	-	Rupees
S	-	Sulphur
SE(m)±	-	Standard error of mean
Sig.	-	Significant
t	-	tonnes
Tmax.	-	Maximum temperature
Tmin.	-	Minimum temperature
Var.	-	Variety
viz.,	-	Namely

(F) **THESIS ABSTRACT**

a. Title of the thesis	: **"EFFECT OF POTASSIUM ON SOIL FERTILITY, NUTRIENT UPTAKE, YIELD AND QUALITY OF PEARL MILLET"** IN INCEPTISOL
b. Name of student	: **DESHMUKH ANIKET RAJENDRA**
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ABSTRACT

A field experiment entitled "Effect of potassium on soil fertility, nutrient uptake, yield and quality of pearl millet Inceptisol" was conducted at Research Farm, Department of Soil Science and Agriculture Chemistry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *kharif* season 2014-2015. The soil of experimental field was clayey in texture, moderately

high in available nitrogen, moderate in available phosphorus, rich in available potassium with slightly alkaline in reaction. Five treatments with various combinations of fertilizer were compared with each other in Randomized Block Design with four replications. The treatments were- 1)NF (no fertilizer)), 2)RDF (recommended dose of fertilizer, 60:30:00 ha^{-1}), 3)RDF+15k_2O (60:30:00 + 15 kg K_2O ha^{-1}), 4)RDF+30k_2O (60:30:00 + 30 kg K_2O ha^{-1}), 5)RDF+45k_2O (60:30:00 + 45 kg K_2O ha^{-1}). Treatments were compared to evaluate the effect of different fertilizer levels on growth, nutrient uptake, yield and economics of pearl millet. Experiment results revealed that fertilizer treatments significantly influenced the growth and yield of pearl millet.

Maximum grain yield (1690 kg ha^{-1}) was recorded with RDF+45k_2O. The second best treatment in this regard was RDF+30k_2O with grain yield of 1660 kg ha^{-1}. Maximum potassium use efficiency (12.63 kg kg^{-1}) was recorded with RDF+30k_2O. The second best treatment in this regard was RDF+45k_2O with grain yield of 9.08 kg kg^{-1} .Both of these treatments were statistically similar with each other. Significantly highest uptake of total NPK was deliberated with treatment of fertilizer consisting 45 kg ha^{-1} of potassium application. It was followed by treatment where potassium was applied to an extent of 30 kg ha^{-1}.

In nutshell it can be inferred that the treatments which received the fertilizer at the rate of 60:30:45 NPK kg ha-1 and 60:30:30 NPK kg ha^{-1}, both being at par with each other, improved the soil fertility status and profitability of the pearl millet crop.

CHAPTER I

INTRODUCTION

1.1 Background Information

Soil fertility and its evaluation is one area which needs immediate attention since it is now established that an arrest in the productivity of several crops is due to ever decreasing soil fertility on one hand and an imbalanced application of plant nutrients on the other. The deficiency of several major and minor plant nutrients such as K, S, Ca, Zn. Fe and B are emerging in time and space (Srinivasa Rao, 2010; Srinivasa Rao and Vittal, 2007; Srinivasa Rao *et al.* 2010, 2007, 2003, 2000a, b, c).

Among the essential plant nutrients, potassium assumes greater significance since it is required in relatively larger quantities by plants and besides increasing the yield, it immensely improves the quality of the crop produce. Although a part of this K gap is expected to be bridged from non-chemical sources like organic manures like composts,vermicompost and biological processes, still there is a distinct gap in nutrient removal and supply leading to nutrient mining from the native soil posing a serious threat to long term sustainability of crop production furthermore, the country like India can hope to achieve and sustain the desired level of agricultural production in the long run only if we can bridge the gap between nutrient removal and addition. Therefore, understanding the present status of K use and removal and the resultant K balances with varied agro-climatic conditions enable us for undertaking the corrective measures to bridge the nutrient gap and help to maintain soil health and ensure the food and nutritional security of present and future generations (Satyanarayana, 2010). In addition, the growing concern about poor soil health and declining factor productivity or nutrient use efficiency has raised concern on the productive capacity of agricultural systems in Maharashtra, especially in Vidarbha region.

Total nutrient consumption increased from 1.46 mt during 1998-99 to 2.33 mt during 2007-08. The consumption of N, P_2O_5 and K_2O

at 1.264, 0.642 and 0.421 mt, recorded an increase of 45.3, 62.5 and 113.7%, respectively, during 2007-08 over 1998-99. The NPK use ratio was 6.5:2.9:1 and per hectare consumption of total fertilizer nutrients in the state during 2011-12 was 144 kg ha^{-1}. Although about 0.421 mt of K was added, the removal was very high at 1.483 mt, leaving a negative balance of 1.062 mt of K (Patil *et al.,* 2001). It is conspicuous that the nutrient use pattern in majority of the agriculturally important states of India is inadequate and mostly dominated by NP fertilization. The negative balance of K is highly predominant in almost all the states which imply that the use of K fertilizers is suboptimal in most cases. Various input and output K balances indicated negative balance of K to the extent of 3 million tonnes annually. Further, refinement of K balances are required by including residue addition in the regions of conservation agriculture practices, green leaf manuring and non-conventional K sources, which may result further reduction of overall negative K balance in Indian agriculture.

Agriculture in Vidarbha region of Maharashtra state is mostly rainfed. In rainfed crops, the importance to K fertilization is not given the attention it deserves, despite significant economic benefits that can be obtained. This is because of farmer's lack of knowledge as well as their reluctance to increase inputs, given the uncertainty of crop cultivation in rainfed conditions. Moreover, as optimal K nutrition is of particular benefit to crops in providing drought tolerance during intermittent dry spells in the rainfed environment, application of K may introduce additional benefits to farmers, beyond remedying the deficient soil K status.

Further, to meet the needs created by population increases, it is estimated that by 2020, India will need an annual production of about 294 mt of food grains, compared with the 230 mt produced today. An additional production of 64 mt of food grains has therefore to be achieved from the same or smaller land area, when degradation of cultivated land and the possible detrimental effects of climate change are taken into account. Proper nutrient management, through efficient, judicious and balanced or integrated use of nutrients coupled with other effective measures in soil and agronomic management, is therefore top priority

(Subba Rao *et al.* 2011). While rainfed agriculture in India represents 58 per cent of the total arable land area of 141 M ha^{-1}, it produces only 40 per cent of the food (Venkateswarlu *et al.* 2012), with the productivity levels of rainfed, dryland crops far below those of irrigated crops. This to some extent may be accounted for by the rainfall-scarce environments of the tropical and sub-tropical regions of the country, which are characterized by arid and semi-arid climate with soil inherently low in organic matter. This is a major component determining soil quality and is strongly related to food security (Srinivasa Rao *et al.* 2012). Increasing the productivity of rainfed cropping systems is therefore an urgent and challenging task to meet the food demands of an ever increasing population.

Pearl millet (*Pennisetum glaucum* (L.)) is one of the major coarse grain crop, and is consider to be a poor man's food. In Vidarbha region, this crop is mostly identified as contingent crop. In Asia it is an important cereal crop of India, Pakistan, China, and south eastern Asia.Pearl millet grains contain about 11.6% protein, 5% fat, 67% carbohydrates and about 2.7% minerals. Its importance can't be ignored because it is the most drought tolerant and has the highest water use efficiency under drought stress.

India is the largest producer of pearl millet in world, both in terms of area (8.69 million ha) and production (10.05 million tonnes) during 2011-12. In India Rajasthan, Maharashtra, Gujarat, Uttar Pradesh and Haryana continue to be the major pearl millet growing states. In Maharashtra during the year 2010-11 area under pearl millet is 10346 ha^{-1}, production is 11234 lakh tonnes and yield is 1086 kg ha^{-1} (Anonymous, 2012).

When ICTP-8203, an open-pollinated variety of pearl millet developed at ICRISAT in 1982 from selection within an iniadi landrace from northern Togo. ICTP-8203 is still cultivated on over 200,000 ha, mostly in Maharashtra, but also in Andhra Pradesh, Karnataka, Rajasthan and Uttar Pradesh. This variety was found to have the highest level of iron density.

Due to intensive cropping, continuous mining and limited use of K fertilizers, soils have begun to show response to K fertilizers along with N, P fertilizers. In view of the above, it was proposed to study the effect of various levels of potassium on soil frtility status,nutrient uptake,yield and quality of pearl millet. The present study examines the impact of increasing levels of K fertilization on productivity, nutrient uptake and quality of rainfed pearl millet in Vidarbha region of Maharashtra state.

1.2 Importance of study

K application has been neglected in many developing countries, including India, which has resulted in soil K depletion in agricultural ecosystems and a decline in crop yields (Regmi *et al.* 2002; Panaullah *et al.* 2006; Ladha *et al.* 2003; Wang *et al.* 2007b; Lal *et al.* 2007). Higher yields and crop quality can be obtained at optimal N:K nutritional ratios. K is an essential macronutrient required for proper development of plants. In addition to activation of numerous enzymes, K plays an important role in the maintenance of electrolytes potential gradients across cell membranes and the generation of turgor. It is also essential for photosynthesis, protein synthesis, and regulation of stomatal movement, and is the major cation in the maintenance of cation-anion balances (Marschner, 1995).

Inadequate application of potassium (K) combined with over application of nitrogen (N) is a serious problem in modern intensive agricultural production systems. It leads to large N losses, environmental pollution and low nitrogen use efficiency (NUE). Although fertilizer consumption is increasing quantitatively, the corresponding yield increase per unit of nutrient has diminished over the years (Sharma and Sharma, 2011; Benbi and Brar, 2011). The response ratio (kg grain/ kg nutrient) in food grain crops in irrigated areas in India substantially declined between 1960 and 2008 (Biswas and Sharma, 2008a). The need to improve NUE is therefore of paramount importance both for economical as well as environmental reasons.

N is probably the major agronomic stimulant to crop growth within the farmer's armoury. But to exploit its maximum use efficiently for increasing crop production, the crop must have access to, and take up, an adequate amount of K from the plant-available (exchangeable K) pool of K in the soil. This is because there is a strong interaction between these two nutrients in crop growth. Crop response to applied fertilizer N decreases when the exchangeable K content of a soil is below a critical target level. Because of this interaction, there is little point in applying large amounts of N when soil is low in available K, because N is used inefficiently and causes financial losses to the grower. There is also the risk that any excess unused fertilizer N lost from the soil will have adverse effects on the environment.

Among several strategies to improve NUE, balanced nutrition, particularly balancing N and K nutrition and tapping into the synergistic effect between N and K, is important both in irrigated as well as rainfed production systems (Ganeshamurthy and Srinivasa Rao, 2001). NUE depends on several agronomic factors including tillage, time of sowing, appropriate crop variety, proper planting or seeding, sufficient irrigation, weed control, pest or disease management, and balanced and proper nutrient use (Srinivasa Rao, 2010). These factors largely influence NUE, either individually or collectively. For example, selection of proper planting material, population density, and balanced fertilization could collectively improve NUE by 25 to 50% (Srinivasa Rao *et al.* 2006).

Considering the decline in K status of soils of Vidarbha and importance of the pearl millet as drought resistance crop, rich in nutrition, it has been decided to undertake the present investigation with the following objectives.

1.3 Objectives

1) To study the effect of various levels of potassium on nutrient uptake, yield and quality of pearl millet.

2) To assess the effect of potassium on soil fertility status.

1.4 Scope and limitation

The potassium status of Indian soils is changing rapidly because of heavy removal of the nutrients from soils under multiple cropping systems with high yielding and fertilizer responsive varieties. Venkatasubbiah *et al.* (1976) observed that the exchangeable potassium decreased from 328 to 96 mg kg^{-1} in an exhaustive study with 17 heavy black soils of West Godavari district of Andhra Pradesh.

Potassium is now considered as an integral component of balanced fertilization. Balanced use of fertilizer is, therefore, essential for achieving high levels of crop productivity in intensive agriculture system. Potassium is relatively abundant in soil but its availability is reported to be quite complicated. It has been observed many a time that the crop would respond to potassium fertilization even in soils of higher potassium status in soils. Potassium deficiency has been reported as fairly widespread (Goswami *et al.* 1976) and is tending to create a greater need for external supply of this nutrient the desired level of production.

Pearl millet contains proteins, carbohydrates, fats, vitamins, iron and mineral salts, which are essential for vigorous growth, health and longitivity of life. Deficiency of any of them would result in malnutrition with its inevitable consequences such as susceptibility to various diseases. Hence, there is a scope to increase the productivity of this crop and making it popular once again among the cultivators by way of posing and testing the effect of graded levels of potash under *Vertisol* condition.

One of the limitations of present study is the threat to increase the cost of cultivation due to addition of potash in the list of recommended dose of fertilizers. However, this threat can be overcome by increasing the productivity from the system and thus making it more economic and adoptable.

1.5. Hypothesis

It has long been supposed that *vertisols* are rich in potassium (K): hence, not much attention was given to K as a crop nutrient. In soil, K is generally considered in relation to the forms of K present: i.e. in solution, exchangeable, non-exchangeable or as a mineral K and the mobilization of K between these pools. Under intensive cropping system, in-solution and exchangeable K (together measured as available K), are readily taken up by roots from the soil solution. This uptake of K induces further release of K from less accessible sources, including the non-exchangeable fraction. Under condition of low K availability the quantity of non-exchangeable K in the soil, its rate of release into the soil solution and the extent to which the K release from this fraction is able to match K demand of the crop are important factors relating to K nutrition of crop plants. In view of this changing scenario, it has become necessary to observe the response of added dose of K to the soil and refine the dose of K application to the pearl millet.

CHAPTER II

REVIEW OF LITERATURE

In this chapter the relevant research work conducted on various crops with different potassium levels is taken up for study. The present investigation are reviewed in brief, in light of their effect on yield, nutrient uptake, quality of crop and soil fertility status.

2.1 Effect of potassium fertilization :

Effect of potassium levels on yield, nutrient uptake, quality and soil fertility status are reviewed here under the following heads.

2.1.1 : Effect of potassium fertilization on Yield

2.1.2 : Effect of potassium fertilization on Nutrient uptake

2.1.3 : Effect of potassium fertilization on Quality parameters

2.1.4 : Effect of potassium fertilization on Soil fertility status

2.1.1. Effect of potassium fertilization on yield

Kumar *et al.* (1989) studied at Agra (UP) and reported that pearl millet significantly responded to varied levels of K. Response to 20 kg K ranged from 0.31 to 2.17 q ha^{-1} with a mean value 0.90 kg grain ha^{-1}, response at 40 kg K ha^{-1} continued to increase the grain yield and ranged from 0.32 to 2.68 q ha^{-1} with mean value 1.01 q grains ha^{-1}. Response at 60 kg K ha^{-1} ranged from 0.50 to 2.63 q ha^{-1} with mean value 1.21 q grains ha^{-1}. The response of pearl millet over a period of five years to K was 0.90, 1.01, and 1.21 q grains ha^{-1} over their corresponding levels of 20, 40 and 60 kg ha^{-1} respectively.

Anuradha and Sarma (1990) reported that application of K @ 33 kg ha^{-1} produced maximum grain yield of sorghum, followed by K @ 49.5 kg ha^{-1}. These were at par but significantly superior to 0 and 16.5 kg K ha^{-1}. The seed yield obtained per kg K was 32.1, 39.7 and 20.9 kg @ 16.5, 33.0 and 49.5 kg K ha^{-1} respectively.

Sharma and Subramanian (1991) reported that application of potassium levels 0 kg, 40 kg and 60 kg ha^{-1} significantly increased the 1000 grain weight, number of grains per ear^{-1}, grain size and yield of sorghum.

Roy *et al.* (1991) found that increasing doses of potassium application significantly increased the grain and stalk yield of maize and also increased up to 32.73 q ha^{-1} giving maximum (19.7%) response at 51 kg K ha^{-1} and minimum (7.3%) response at 17 kg K ha^{-1}.

Talukdar and Khera (1991) reported that application of potassium @ 0, 50 and 100 kg ha^{-1} significantly increased the grain yield up to 26.56, 29.78 and 32.38 q ha^{-1} in pearl millet respectively, during three years.

Prasad and Prasad (1993) studied the response of maize to potassium application and found that grain yield varied as 56.3, 62.5 and 68.8 q ha^{-1} @ 0, 30 and 60 kg K ha^{-1} respectively.

Sarma (1993) reported that sorghum responded to potassium by significantly increasing 1000 grain weight, yield increased by 29% compared with control in both the high and medium K soils, at 33 kg K ha^{-1}.

Sarma and Ramana (1993) reported that application of potassium @ 0, 40 and 80 kg K_2O ha^{-1} resulted in the increase in yield of sorghum up to 3949, 5476 and 5582 kg ha^{-1} respectively.

Raghuwanshi and Umat (1994) revealed that increasing fertility level significantly increased the mean yield of sorghum. Fertility level of 120 kg N + 60 kg P_2O_5 + 40 K_2O kg ha^{-1} gave maximum grain yield (44.60 q ha^{-1}).

Sharma and Anuradha (1994) recorded that application of potassium @ 33 kg ha^{-1} improved the yield of sorghum by 29% over 0 kg K ha^{-1}.

Anand Swarup (1995) reported that application of potassium had significantly increased the grain yield of pearl millet.

Kamalakumari and Singaram (1996) revealed that successive increase in NPK levels reflected in corresponding significant rise in grain yield of maize by 1263, 2563, 2913 and 3488 kg ha^{-1} @ 0, 50%, 100%, and 150% NPK respectively.

Sharma and Shanta Kumari (1996) found that sorghum response to applied potassium was the highest (10.8 kg grain kg^{-1} K) @ 33 kg ha^{-1}. There was a yield increase of 17 per cent and 13 per cent during 1988-89 and 1989-1990, respectively over the control.

Sarma and Ramana (1996) reported that test weight (1000 grain weight) was found to be increased by 4.3% for applied potassium at 33 kg ha^{-1} over the control. While the effect of applied K @ 33 kg ha^{-1} was at par with that for 66 kg ha^{-1} and recorded 38.7% more grain yield over the control.

Santhi *et al.* (2003) observed that maize responded significantly to potassium application by yielding 3140 and 3350 kg ha^{-1} at 100% NP and 100% NPK respectively.

Akram *et al.* (2007) reported that application of P_2O_5 (80 kg ha^{-1}) and K_2O (40 kg ha^{-1}) to sorghum resulted in higher biological yield (31.7 t ha^{-1}) and grain yield (2.26 t ha^{-1}) respectively over the control.

Yadav *et al.* (2007) revealed that application of potassium @ 0, 20, 40 and 60 kg K ha^{-1} resulted in significant increase in the yield of pearl millet up to 2.4, 2.6, 2.8 and 2.9 mt ha^{-1}, respectively.

They found that pearl millet crop responded significantly in up to 30 kg K_2O ha^{-1} at both levels of nitrogen. The increase in grain yield was 11.61 and 16.65% with 90 kg N ha^{-1} whereas this increase was 11.67 and 17.46% with 120 kg N ha^{-1} at 30 and 60 kg K_2O ha^{-1}, respectively over the control.

Magan and Nosov (2008) reported that application of 125 kg N ha^{-1} and 30-90 kg K kg^{-1} result in increase in yield of maize crop by 200-1300 kg ha^{-1}.

Yadav *et al.* (2008) reported that increase in grain yield of pearl millet in pearl millet-wheat cropping system was 11.61 and 16.65 per cent with 90 kg N ha^{-1} whereas this increase was 11.67 to 17.46 per cent with 120 kg N ha^{-1} at 30 and 60 kg K_2O ha^{-1}, respectively over control.

They also investigated that increase grain yield of pearl millet in pearl millet-mustard cropping system was 4.80, 9.48 and 14.14 per cent at 20, 40 and 60 kg K_2O ha^{-1}, respectively over control.

Further they reported that pearl millet crop responded significantly up to 30 kg K_2O ha^{-1} with both levels of N. The increase in grain yield of pearl millet was 11.61 and 16.65 per cent with 90 kg N ha^{-1} whereas this increase was 11.67 to 17.46 per cent with 120 kg N ha^{-1} at 30 and 60 kg K ha^{-1}, respectively over control.

Yadav *et al.* (2008) revealed that increase in pearl millet grain yield was 4.80, 9.48 and 14.14 per cent with 20, 40 and 60 kg K_2O ha^{-1}, respectively over control.

Prasad (2009) reported that pearl millet responded significantly to potassium by increasing the yield was 1.05, 1.24 and 1.65 mt ha^{-1} at control, N alone and NPK respectively.

Girase *et al.* (2010) found that pearl millet responded significantly to potassium application by increase in grain yield of 16.13, 21.18 and 25.86 q ha^{-1} @ 0, 20 and 30 kg K ha^{-1}.

Heidari and Jamshid (2010) reported that application of potassium fertilizer significantly increased grain yield and yield components in pearl millet by application of 0 to 200 kg K ha^{-1}, grain yield (11.7%), biological yield (24.2%) and 1000 seed weight (41.1%) increased.

Muralidharudu and Tondon (2010) revealed that application of balanced NPK fertilizers recorded significant increase in grain yield by 79% and 93% over the control in pearl millet and maize respectively.

Mansoor *et al.* (2010) reported that application of NPK fertilizers @ of 80-50-25 kg ha^{-1} resulted in maximum grain fodder yield

(76.00 t ha^{-1}, 81.33 t ha^{-1} and 65.67 t ha^{-1}) in all three years, respectively while the minimum grain fodder yield (39.33 t ha^{-1}, 41.00 t ha^{-1} and 29.33 t ha^{-1}) was obtained in control treatment in all the three years, respectively.

Ashiq *et al.* (2011) recorded that application of potassium significantly increased the grain and stover yield of sorghum and maize.

Dwivedi *et al.* (2011) revealed that with application of 150: 62: 105 kg NPK ha^{-1} the grain yield of pearl millet was 4.12 t ha^{-1} (86.4%) over the farmer fertilizer practises (1.91 t ha^{-1}).

Singh *et al.* (2011) observed that application of 180 kg N ha^{-1}, 38.7 kg P_2O_5 and 74.7 kg K_2O ha^{-1} significantly increased the grain yield of maize.

Brar *et al.* (2012) found that significant increase in grain yield of maize was observed with the increase in levels of applied potassium, the grain yield increases from 5.69 to 6.54 mt ha^{-1} at 0 to 60 kg K_2O ha^{-1}.

Paramasivan *et al.* (2012) reported that application of levels of potassium to maize (50, 66, 88 and 110 kg K_2O ha^{-1}) significantly increased the length of cob, girth of cob, 100 grain weight, grain and fodder yield over the control.

Priyadarshani *et al.* (2012) reported that grain yield of pearl millet was influenced by various levels of fertilizer significantly grain yield 2.08, 2.65, 3.50, 3.57 and 3.68 t ha^{-1} was recorded in treatment that received 0 (control), 100% N, 100% NP, 100% NPK and 150% NPK ha^{-1}.

Srinivasa Rao and Surekha (2012) reported that sorghum grain yield improved from 2.8 t ha^{-1} to 3.74 t ha^{-1} at 60 kg K ha^{-1} Maize responded to K application substantially by increasing the yield of 18%, 25% and 33% respectively at 20, 40 and 60 kg K_2O ha^{-1}.

Singh and Majumdar (2012) studied the pearl millet yield responses across sites and years it varied considerably with an average of 1,333, 816, 359, and 155 kg ha^{-1} for N, P, K, and S, respectively at nitrogen, phosphorus, potassium and sulphur treatment of 120 kg N, 70 kg P_2O_5, 100 kg K_2O, and 30 kg S ha^{-1} respectively.

Singh and Wanjari (2012) reported that grain yield of sorghum was influenced by various levels of fertilizer and found to be significant grain yield of 290, 1975, 2701, 3353 and 4204 kg ha^{-1} that was recorded in treatment receiving 0 (control), N, NP, NPK and 150% NPK respectively.

Tamboli *et al.* (2012) found that application of potassium to sorghum resulted in significant increase in grain and stover yield over no potassium. Supply of 25 kg K ha^{-1} registered higher grain (12.11 q ha^{-1}) and stover (36.64 q ha^{-1}) yield which was on par with 50 kg K ha^{-1}.

Yadav *et al.* (2012) reported that pearl millet crop responded significantly to K residual effect at 60 kg K ha^{-1} under both levels of nitrogen. The increase in mean grain yield was 4.6 and 11.3% with 90 kg N ha^{-1} and 4.7 and 11.1% with 120 kg N ha^{-1} due to residual effect of 30 and 60 kg K ha^{-1} respectively over the control.

Kumari *et al.* (2013) reported that maize crop responded significantly to potassium application 1.64, 1.64, 2.17 and 2.64 grain yield t ha^{-1} was obtained with 0, 100% N, 100% NP and 100% NPK respectively.

Jat *et al.* (2013) reported that application of 100% NPK increased grain (45.3 and 44.6%) and stover (12.2 and 12.3%) yields of sorghum respectively over the control.

Mangal *et al.* (2013) indicated that application of balanced NPK significantly increased the grain yield of maize up to 1719, 2560, 3089, 3480 and 3990 kg ha^{-1} at 0, 100% N, 100% NP, 100% NPK and 125% NPK.

Srinivasa Rao (2013) reported that sorghum grain yield raised from 2.8 mt ha^{-1} (control) to 3.74 mt ha^{-1} at 60 kg K ha^{-1} (33 per cent increase). Maize too responded substantially to potassium application, by increased of 18, 25 and 33 per cent respectively over the control, at 20, 40 and 60 kg K ha^{-1}. Similarly, straw yields of sorghum and maize were significantly increased by 19 and 32 per cent at 60 kg K ha^{-1}.

2.1.3. Effect of potassium fertilization on nutrient uptake

Roy *et al.* (1991) reported that total uptake of potassium by pearl millet had shown significant variation with increasing doses of potassium application. It was highest (72.42 kg K ha^{-1}) at 51 kg K ha^{-1} level and the lowest at (51.15 kg K ha^{-1}) in no K fertilizer treatment.

Solankey *et al.* (1991) observed that more soil K conservation and increasing the total K uptake through higher utilization of fertilizer K and ultimately augmented the grain yield of sorghum significantly.

Talukdar and Khera (1991) reported that application of potassium @ 0, 50 and 100 kg ha^{-1} significantly increased the K uptake in bajra up to 249.69, 284.00 and 312.04 kg ha^{-1}respectively.

Singh *et al.* (1992) reported that uptake of potassium in pearl millet and maize crops increased significantly with increasing levels of potassium.

Sarma and Ramana (1993) reported that sorghum crop responded potassium application by increasing uptake of N, P and K with application of 0, 40 and 80 kg K ha^{-1} respectively over the control.

Anand Swarup (1995) reported that application of K significantly enhanced the P and K uptake by pearl millet.

Kamalakumari and Singaram (1996) reported that successive increase in NPK levels reflected in corresponding significant rise in NPK uptake by maize grains.

Sharma and Shanta Kumari (1996) reported that application of potassium at 33.0 kg K ha^{-1} improved the potassium uptake by sorghum in black soil.

Akram *et al.* (2007) reported that with the application of P_2O_5 (80 kg ha^{-1}) and K_2O (40 kg ha^{-1}) to sorghum the uptake of nutrient like nitrogen, phosphorus and potassium was 239.5, 29.7 and 146.3 kg ha^{-1} respectively over the control of 173.6, 23.4 and 109.5 kg ha^{-1}.

Yadav *et al.* (2007) found that application of potassium significantly increased the pearl millet K uptake in pearl millet-mustard cropping system. Grain K uptake was increased by 0.84, 1.94 and 2.78 kg ha^{-1}, with corresponding increased in straw K uptake of 18.45, 51.75 and 72.97 kg ha^{-1} @ 20, 40 and 60 kg K ha^{-1} respectively over the control. They also investigated that application of potassium significantly increased K uptake by pearl millet-wheat crops. The increase in pearl millet grain K uptake was at 30 and 60 kg K ha^{-1} respectively over the control.

Yadav *et al.* (2008) reported that potassium application also increased K uptake by pearl millet and wheat crops. The initial mean available potassium status of soil was 160.3 kg K ha^{-1} which decreased to 125.9, 141.1 and 151.0 kg K ha^{-1} with lower N level and to 124.6, 138.3 and 149.7 kg K ha^{-1} with high N levels, respectively after the harvest of continuous five years of pearl millet-wheat crop rotation.

Heidari and Jamshid (2010) reported that application of potassium fertilizer significantly increased nutrient uptake in pearl millet leaf potassium, magnesium and sodium by application of 0 to 200 kg K_2O ha^{-1}.

Muralidharudu and Tondon (2010) reported that application of balanced NPK fertilizer recorded significant increase in nutrient uptake by 85% N, 95% P_2O_5 and 104% K_2O respectively over the control in pearl millet.

Paramasivan *et al.* (2010) found that application of potassium significantly increase nutrient uptake, the highest total N uptake (247.47 kg ha^{-1}) of maize in Madhukkur series was noticed in the treatment with 250:70:150:9.6 kg of NPK and Zn ha^{-1}. The application of 200:87.5:150:9.6 kg of NPK and Zn resulted in the highest total P uptake (73.53 kg ha^{-1}). The highest total K uptake (207.42 kg ha^{-1}) was recorded with for the treatment of 200:64:187:4.8 kg of NPK and Zn ha^{-1}.

Singh *et al.* (2011) reported that application of 180 kg N ha^{-1}, 38.7 kg P_2O_5 and 74.7 kg K ha^{-1} significantly increased N, P and K uptake by maize.

Yadav *et al.* (2011) revealed that potassium fertilization also significantly increased K uptake by pearl millet in pearl millet-mustard cropping system. It was increased by 12, 16 and 36% @ 20, 40 and 60 K ha^{-1}, respectively over the control.

Brar *et al.* (2012) found significant increase in N and K uptake by maize seeds with the increase in levels of applied K. The N uptake into the grain, which on average was 40.2 kg ha^{-1}, increased to 44.2, 45.5 and 50.9 kg ha^{-1}, and K uptake which on average was 19.4 raised to 20.9, 23.2 and 26.8 kg ha^{-1} @ 0, 30, 60 and 90 kg K ha^{-1}.

Paramasivan *et al.* (2012) reported that application of levels of potassium (50, 66, 88 and 110 kg K ha^{-1}) significantly increased nutrient uptake of NPK over the control in maize.

Singh and Wanjari (2012) found significant potassium uptake of 9.31, 107.20, 146.0 and 190.5 kg ha^{-1} in treatment receiving 0 (no fertilizer), N, NP, NPK respectively.

Singh and Majumdar (2012) reported that maximum total uptake of N, P and K was recorded with the application 120:70:100 kg^{-1} NPK by pearl millet.

Srinivasa Rao and Surekha (2012) reported that application of potassium @ 20, 40 and 60 kg K ha^{-1} significantly increased the nutrient uptake in sorghum and maize crops.

Tamboli *et al.* (2012) observed that application of potassium to sorghum varieties resulted in significant increase in total K uptake and soil available K compared to check plots. Application of 25 kg K ha^{-1} resulted in higher total K uptake by sorghum (84.4 kg ha^{-1}) but it was on par with 50 kg K ha^{-1} and 37.5 kg K ha^{-1}. However, application of 50 kg K ha^{-1}

resulted in significantly higher soil available K (853 kg ha^{-1}) which was on par with 37.5 kg K ha^{-1}.

Yadav *et al.* (2012) reported that pearl millet mean grain K uptake was higher by 0.64 and 1.44 kg ha^{-1} with 90 kg N ha^{-1} and by 0.82 and 1.88 kg ha^{-1} with 120 kg N ha^{-1} with 90 kg N ha^{-1} and by 11.80 and 25.66 kg ha^{-1} with 120 kg N ha^{-1} at 30 and 60 kg K ha^{-1}, respectively.

Jat *et al.* (2013) reported that improvement in N, P and K content and their uptake in sorghum grain (61.6, 15.3 and 22.0%) and stover (84.7, 29.9 and 243.2%) with 100% NPK over control.

Srinivasa Rao (2013) reported that application of potassium to sorghum and maize crops significantly increased in K uptake in both the crops at the rate 0, 20, 40 and 60 kg K_2O ha^{-1}.

2.1.4. Effect of potassium fertilization on Quality Parameter :

Nagre *et al.* (1991) recorded that the maximum protein (36.3 per cent) and oil (20.3 per cent) contents of soybean were obtained with 60+45+45 kg NPK ha^{-1} there was progressive and significant increased in protein and oil content with increasing fertilizer levels.

Asghar *et al.* (1994) found that application of 75 kg K_2O in addition to 25 and 75 kg N and P_2O_5 kg ha^{-1}. Showed a significant increased in improved seed protein contents of blackgram.

Deshmukh *et al.* (1994) conducted field experiment at two location Akola and Amravati on vertisol and observed that K levels had significant positive effect on protein and oil content of soybean. The maximum protein content was recorded at 90 kg K_2O ha^{-1} at both locations while the highest protein yield was obtained at 60 and 90 kg K_2O ha^{-1} at Amravati and Akola respectively.

Basith *et al.* (1995) reported that application of increased levels of potash showed positive influence on oil and protein content of groundnut kernel up to 30 kg K_2O ha^{-1} in case of oil (48.99 per cent).

Umar and Bansal (1997) reported that application of 20 kg K ha^{-1} enhanced protein content and oil content in groundnut.

Singh and Prasad (1997) found that potassium application significantly increased dry matter production, grain yield, test weight, carbohydrate and ash content over control in chickpea

Abdalla *et al.* (1998) reported ash content values ranging from 1.8 to 2.4% for flours from pearl millet genotypes. Ash content of 2.1, 2.1, 2.7 and 1.9% for raw, germinated, roasted and fermented millet flours, respectively, the reduction in ash content of pearl millet-acha flour blends with increasing proportions of pearl millet flour could be due to the low ash content of the pearl millet grains.

Selma *et al.* (2001) effect of natural fermentation on nutritive value and in vitro protein digestibility of pearl millet shows the fat contents Crude protein was 10.8% for Composite Pop. III. and 14.9% for Baladi The values obtained in this study were within the range of 9–20% reported by Desai and Zendi (1979). Sullivan et al. (1990) reported that protein content for pearl millet ranged from 8 to 19%.

Asghar *et al.* (2006) observed that protein contents of mungbean seed were significantly affected by different potash levels.

Thalooth *et al.* (2006) reported that foliar application of potassium (2.0% KNO_3)' significantly surpassed the other treatments with respect to crude protein percentage in mungbean.

Ali *et al.* (2007) found that the seed protein contents also increased gradually with an increase in potash levels and maximum protein content (23.87%) were recorded with application of 150 kg K_2O ha^{-1} in chickpea.

Kharade *et al.* (2010) recorded that maximum protein content with the application of 40 kg K_2O/ha and was at par with 50 kg K_2O/ha on Vertisol (23.1%) followed by Inceptisol(22.6%).

Singh *et al.* (2010) reported that urad contains about 24% protein, 60% carbohydrates, 1.3% fat, and is the richest among the various pulses in phosphoric acid, being five to ten times richer than in others.

Farhad *et al.* (2010) reported that highest protein content in seed (42.23%) was recorded (40 kg K ha^{-1}) in soybean.

Heidari *et al.* (2010) studied on interaction between salinity and potassium on grain yield, starch content and nutrient uptake in pearl millet which was resulted the rate of potassium treatment was 0, 100 and 200 kg ha^{-1}. Pearl millet was subjected to different salinity levels (0, 4, 8 and 12 dsm^{-1}) through addition of NaCl to irrigation water. Results showed by 1000 seed weight (60.1%) decreased. In this study salt stress remarkably elevated the carbohydrate content at vegetative and reproductive stages in leaves of millet.

Vanisha *et al.* (2011) studied on the potential functional implications of pearl millet and which was resulted the finger, teff, and kodo millets have similar amounts of lysine to pearl millet. However, as compared to maize, pearl millet is 8-60% higher in crude protein and 40% richer in amino acid lysine and methionine.

Satinder Kaur *et al.* (2011) studied on to functional properties and anti-nutritional factors in cereal bran which was resulted the various cereal brans (wheat, rice, barley and oat) were investigated for proximate composition, functional characteristics and certain anti-nutritional factors to assess their potentiality as protein and fibre sources. Crude protein ranged from 9.6- 15.03%, fat 4.07-19.31%, dietary fibre 14.0-38.95%.

Tiwari *et al.* (2012) observed that protein content in pigeonpea grain increased from 21.01 percent in the control to 21.95 percent at the highest K treatment K_{80}.

Ayub *et al.* (2012) studied on to effect of different levels of P and K on cluster bean (cyamopsis tetragonolobus l.) the phosphorus and potassium were applied in eight different combinations. The results revealed that above ground plant measures of nutritional profile like crude protein, crude fibre and ash contents were significantly improved with phosphorus and potassium application over control. The highest crude fibre and ash contents in plant dry matter was produced with 100-100 kg PK ha-1. The crude protein contents showed a steady increase in crude protein up to 85-85 kg PK ha^{-1}. For obtaining high yield with good nutritional value, PK fertilizer must be applied at the rate of 85-85 kg ha -1 under the irrigated conditions of Faisalabad.

Tabatabaei and Ranjbar (2012) studied on effect of different levels of nitrogen and potassium on grain yield and protein of triticale which results of this study indicate that the application of different levels of nitrogen affected grain protein of triticale significantly, however using different amount of potassium had effect on grain protein up to the rate of grain protein by application of potassium levels was approximately 12.6 %. The interaction of different levels of nitrogen and potassium on grain yield and protein was significant.

Abagale *et al.* (2013) recorded the biochemical relevance of sorghum and millet produced in the Kasena - Nankana districts of Ghana, the proximate results for the first farming season of the study indicated that the highest average crude protein(12.2%), and fibre(5.4%) were in the sorghum bicolor; carbohydrates(83.1%) in the proso millet; fat(4.2%) and ash(1.6%) where as K (668.0 mg/kg) was highest in both red sorghum and pearl millet.In the second season, the highest average amount of crude protein(14.4%),ash(2.1%) and fibre (3.5%) were in the white sorghum, and carbohydrates(76.2%) in the red sorghum. The working moisture ranged from 8.2-17.7%. all in the red sorghum. K(690.0 mg/kg).

2.1.4. Effect of potassium fertilization on soil fertility status

Tejagouda Bhanuje *et al.* (2014) effect of staggered sowing and split application of nitrogen in seed production of pearl millet hybrid MH-946 he resulted that irrespective of staggered sowings, the soil application of nitrogen did not exhibit marked variations on plant height. The soil application of 50% N at the time of sowing + 25% N at 25 DAS +

25% N at 35 DAS to male parent (S3) recorded more plant height (180.1 cm) at harvest when compared to 50% N at the time of sowing and 50% N after 15 DAS (S1) (178.9 cm).

Brar M.S. *et al.* (2010) effect of Potassium Nutrition on the Yield, Quality and Nutrient Uptake by Sunflower. Field experiments at farmers fields were conducted at 21 locations in Hoshiarpur, Ropar and Nawanshehar districts of Punjab during 2003 to 2007. The experiments were laid out in a randomized block design with three replications. Physico-chemical characteristics of the experimental soils were estimated by following standard procedures. Available potassium was estimated by extracting the soil with neutral normal ammonium acetate solution (Merwin andPeech 1950). The size of plot was 800 m2.

Ahmad and Sharma (2009) revealed that, application of FYM alone or in combination with chemical fertilizers increased soil organic carbon content after harvest of wheat crop. Reasons attributed are the direct incorporation of organic matter, better root growth and more plant residues addition after harvest of crops. Further the organic carbon content of the soil also increased significantly with the application of 100% NPK. However, the pH and electrical conductivity of soil were not reflected to a considerable extent.

Rathor and Sharma (2009) revealed that, significant improvement in soil and fertility status was found under treatment (T20) comprising of 100% NPK + vermi-compost + Zinc + PSB. Organic carbon content of soil improved from 3.0 to 4.6 g kg^{-1} soil. Available N from 197.0 to 219.0 kg ha^{-1}, available P from 13.56 to 23.52 kg ha^{-1} and potassium 315 to 340 kg ha^{-1}.

Kundu et al. (2008) reported that after 27 years of cropping there was increase in SOC content with the treatment of NPK + FYM as compared to control

Yang *et al.* (2007) noticed that Fertilization is one of the major and direct agronomic practices that can increase SOC by alleviating nutrient deficiencies in crops, thus increasing C inputs to soil. In most long-term experiments, applications of fertilizer nutrients are limited to N, P, and potassium (K).

Agrawal *et al.* (2007) observed that, the available N, P and positively correlated with organic carbon. In general all the soil was sufficient in cationic micronutrient due to acid soil condition.

Singh and Wanjari (2006) reported that the three was improvement in available N in Vertisols of Jabalpur in the treatment of management practice i.e. NPK + FYM in the long term fertilizer experiment.

Hadwani G. J. *et al.* (2005) effect of N, P and K Levels on Yield, Nutrient Content, Uptake and Quality of Summer Groundnut Grown on Typic Haplustepts. The results indicated that the pod and haulm yield of groundnut significantly increased with increasing levels of N, P and K.. The application of NP increased the pod and haulm yield by 5.7, 14.0 and 26.4 and 34.9% with the application of R100 and R150, respectively over control (R0). Oil and protein yields of groundnut also increased significantly over control.

Singh *et al.* (2005) proved that, application of K significantly reased the availability of K and also increased the organic carbon content of soil.

Patel *et al.* (2001) reported that, pigeon pea was the most efficient exploiter of N, P and K from soil. It was also found to make the best use of applied N and K.

Krishnan and Lourduraj (1997) noted that there is slight increased in organic carbon content in soil over initial values may be due to addition of fertilizer into soil.

Malewar and Hasnabade (1995) while working on crop rotation in vertisol at Parbhani, reported that application of inorganic fertilizers increased organic carbon and available P but lowered available K and bulk density.

Tyagi and Bhardwaj (1994) proved that, the graded application of NPK fertilizers significantly increase N, P and K availability relative to the control as did the application of FYM and biofertilizers. Addition of potassium K (100%NP) increased available K status by 16.3 kg ha^{*1}.

Prasad (1993) reported that the effect of potassium on soil p^H was found to be non-significant at surface layer of soil (0-30 cm).

Hasan and Chattopadhyay (1992) proved that, the application of NPK fertilizer result in large increase in the P and K content of the alluvial soil. N and K content were large in the upper (0 - 20 cm) soil layer, but P content decreased with depth.

high in available nitrogen, moderate in available phosphorus, rich in available potassium with slightly alkaline in reaction. Five treatments with various combinations of fertilizer were compared with each other in Randomized Block Design with four replications. The treatments were- 1)NF (no fertilizer)), 2)RDF (recommended dose of fertilizer, 60:30:00 ha^{-1}), 3)RDF+15k (60:30:00 + 15 kg K_2O ha^{-1}), 4)RDF+30k (60:30:00 + 30 kg K_2O ha^{-1}), 5)RDF+45k (60:30:00 + 45 kg K_2O ha^{-1}). Treatments were compared to evaluate the effect of different fertilizer levels on growth, nutrient uptake, yield and economics of pearl millet. Experiment results revealed that fertilizer treatments significantly influenced the growth and yield of pearl millet.

Maximum grain yield (1690 kg ha^{-1}) was recorded with RDF+45k. The second best treatment in this regard was RDF+30k with grain yield of 1660 kg ha^{-1}. Both of these treatments were statistically similar with each other. Significantly highest uptake of NPK was deliberated with treatment of fertilizer consisting 45 kg ha^{-1} of potassium application. It was followed by treatment where potassium was applied to an extent of 30 kg ha^{-1}.

In nutshell it can be inferred that the treatments which received the fertilizer at the rate of 60:30:45 NPK kg ha-1 and 60:30:30 NPK kg ha^{-1}, both being at par with each other, improved the soil fertility status and profitability of the pearl millet crop.

CHAPTER III

MATERIAL AND METHODS

A field experiment entitled "Effect of potassium on soil fertility, nutrient uptake, yield and quality of Pearl millet in Inceptisol" was conducted during *kharif* season of 2014-15. The details of material used and methods adopted during the course of investigation are described in this chapter under the following heads.

3.1 : Location of Experimental site

3.2 : Climate and weather conditions

3.3 : Soil characteristics of experimental site

3.4 : Experimental details

3.5 : Treatment details

3.6 : Cultural practices

3.7 : Quality parameters

3.8 : Chemical studies

3.9 : Nutrient uptake

3.1: Location of Experimental site

The field experiment was carried out at the Research farm of the, Department of Soil Science and Agricultural Chemistry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola.

3.2:Climate and weather conditions

Akola is situated in the subtropical region at $22^0$42' North latitude and 77^0 02' East longitudes and at an altitude of 307.42 m (Agromet observatory) above mean sea level. The climate of Akola is semi-arid and characterized by three distinct seasons viz., hot and dry summer from March to May, warm and rainy monsoon from June to October and mild cold winter from November to February. Average annual precipitation was 740 mm (Average of 30 years). During crop growing period, the actual maximum temperature was 34.2^{0}C during the hottest month of September while the minimum temperature was 9.8^{0}C in the coldest month of December. The mean daily evaporation reaches as high as 5.7 mm in the month of September and was 2.6 mm in the month of July. The mean wind velocity varies from 11.6 km hr^{-1} during August to 0.8 km hr^{-1} during October. Relative humidity attains the maximum value (89-95%) during July-August and the minimum (21-76 %) during December January.

The weather data during the year 2014 -15 at Akola centre are given in Table 1 discussed as below.

The monsoon commenced in the first week of July and sowing of pearl millet experiment were under taken on August 1 (31th MW). The amount of rainfall received during the cropping season was 301.02 mm in 19 rainy days was mainly concentrated in June, July, August and September as against the normal of 572.1 mm in 30 rainy days. Rainfall received during the season (265.00 mm) was 307.1 mm less over the average normal rainfall. Rainfall distribution during important crop growth stages was erratic and uneven. Crop emergence was noticed on 9 August. After emergence, there were good showers during the month of August (98.4 mm, 11 rainy days), September (137.5 mm, 5 rainy days),October (00 mm, 0 rainy days) and November (20.1mm,2 rainy days) which favored crop growth and inter culture operation were carried out satisfactory. Hence, crop growth improved subsequently.

During this year onset of Monsoon was in the 22rd and 23th MW (on 3th June), which was normal. Sowing of cotton experiment was done 1st August. Emergence of pearl millet was satisfactory because of sufficient rains before sowing and frequent rains after sowing in 33, 34th MW.

Table1 : Weekly Weather data for the year 2014 recorded at Meteorological Observatory Department of Agronomy Dr. PDKV., Akola

		Actual				2014										Normal		1971-2010		
Weeks	Dates	T MAX (°C)		T MIN (°C)		BSH (hrs)		WS (km/hr)		RH I (%)		RH II (%)		Evap (mm)		RF (mm)		CRF (mm)	Rainy Days	
		N	A	N	A	N	A	N	A	N	A	N	A	N	A	N	A		N	A
1	1-7 Jan	28.8	29.0	11.0	13.0	8.2	4.8	4.4	1.0	71	80	31	31	4.2	4.4	2.8	0.0	0.0	0.2	0.0
2	8-14	29.3	28.5	11.7	13.9	8.3	4.6	4.4	2.3	71	80	30	34	4.4	3.7	3.3	0.0	0.0	0.2	0.0
3	15-21	30.0	29.2	12.0	15.8	8.6	3.4	4.5	2.0	68	76	28	33	4.9	4.7	0.7	0.4	0.4	0.1	0.0
4	22-28	30.6	28.9	12.0	14.5	8.8	3.3	4.6	1.9	65	81	26	31	5.2	4.2	0.9	0.0	0.4	0.1	0.0
5	29-4 Feb	31.0	30.0	12.6	11.0	8.8	8.4	4.9	1.7	62	59	25	16	5.5	5.2	3.0	0.0	0.4	0.2	0.0
6	5-11	31.4	31.9	12.7	14.0	8.8	7.6	5.0	1.7	59	60	23	20	5.9	5.3	3.7	0.0	0.4	0.3	0.0
7	12-18	32.7	29.4	14.4	12.7	9.0	7.4	5.4	2.3	55	64	22	24	6.6	6.7	0.1	0.0	0.4	0.0	0.0
8	19-25	33.4	31.7	14.5	16.2	9.1	5.9	5.7	2.0	54	64	21	29	7.3	6.2	2.5	2.0	2.4	0.2	0.0
9	26-4 Mar	35.0	30.2	15.7	15.3	9.5	7.5	6.1	2.8	50	76	18	25	8.2	5.7	4.1	34.7	37.1	0.3	3.0
10	5-11	35.9	28.9	17.3	16.5	9.2	6.0	6.1	3.1	46	83	20	29	8.8	4.4	5.2	8.6	45.7	0.3	2.0
11	12-18	37.0	35.3	18.1	18.9	9.1	8.7	6.3	2.2	45	70	18	16	9.2	6.5	2.4	7.9	53.6	0.3	1.0
12	19-25	38.4	37.8	19.3	20.0	9.2	8.7	6.4	2.8	39	43	15	11	10.4	9.7	0.6	0.0	53.6	0.1	0.0
13	26-1 Apr	39.0	39.8	20.4	23.7	9.2	8.0	6.9	2.8	37	35	15	11	11.2	9.5	2.2	0.0	53.6	0.2	0.0
14	2-8 Apr	40.0	39.9	21.7	22.2	9.4	8.0	7.3	3.1	37	30	14	9	11.7	10.2	1.0	0.0	53.6	0.1	0.0
15	9-15	40.8	39.3	23.1	21.8	9.5	7.5	8.4	3.5	35	38	14	10	12.9	10.6	0.4	0.0	53.6	0.1	0.0
16	16-22	41.6	40.4	24.1	23.8	9.7	8.2	8.6	3.5	36	52	14	22	13.9	10.7	0.5	4.2	57.8	0.1	1.0
17	23-29	42.3	41.5	25.4	24.2	9.8	8.7	9.0	3.8	37	38	15	11	14.7	12.7	0.5	0.0	57.8	0.1	0.0
18	30- 6 May	42.6	42.6	26.6	25.5	9.4	8.3	10.5	3.2	39	38	15	11	15.5	11.7	0.8	6.4	64.2	0.1	1.0
19	7-13	42.6	39.3	27.1	25.8	9.7	6.6	12.2	6.4	42	56	17	21	16.2	10.8	1.3	0.8	65.0	0.1	0.0
20	14-20	42.5	41.2	27.7	26.5	9.4	7.5	14.2	5.1	47	46	19	21	16.8	11.7	2.8	0.0	65.0	0.4	0.0
21	21-27	42.1	43.3	27.8	27.2	9.5	7.2	15.1	6.7	50	47	20	16	16.9	13.1	3.8	3.2	68.2	0.4	0.0
22	28-3 Jun	41.7	43.6	27.8	28.3	9.4	8.3	15.2	7.1	53	48	23	21	16.2	11.8	6.3	4.5	72.7	0.4	1.0
23	4-10	40.2	43.0	26.9	29.6	8.4	6.5	15.2	10.9	62	49	30	26	14.0	16.6	16.8	0.0	72.7	1.0	0.0
24	11-17	38.0	39.3	25.7	25.3	7.1	8.5	13.4	10.4	69	66	40	28	11.1	13.2	43.6	22.5	95.2	1.7	2.0
25	18-24	35.5	37.2	25.0	26.8	5.8	4.7	14.2	14.6	74	63	48	31	9.2	14.3	43.5	1.5	96.7	2.0	0.0
26	25-1Jul	33.8	38.2	24.3	26.8	4.8	5.2	12.8	15.0	80	61	55	31	7.4	14.3	43.4	1.7	98.4	2.2	0.0
27	2-8	33.2	36.4	24.0	26.3	4.8	4.1	12.0	12.5	81	74	58	44	6.5	11.9	39.4	1.4	99.8	2.2	0.0
28	9-15	32.3	35.1	23.8	24.7	3.8	2.8	11.2	10.0	83	84	60	51	5.5	6.8	42.8	48.6	148.4	2.5	1.0
29	16-22	31.9	30.7	23.6	23.9	4.0	1.5	10.4	8.8	84	88	63	70	5.2	3.8	52.8	45.8	194.2	2.4	6.0
30	23-29	31.3	28.2	23.3	22.6	4.0	1.2	10.8	11.4	86	90	64	68	4.8	4.7	43.4	194.2	388.4	2.6	3.0
31	30-5 Aug	30.9	31.6	23.3	24.2	3.5	3.2	10.6	7.6	86	89	67	66	4.6	6.0	49.6	16.4	404.8	2.4	1.0
32	6-12	29.9	32.2	23.0	23.6	3.2	5.9	10.9	11.9	88	87	70	48	4.1	8.3	61.0	13.7	418.5	2.8	2.0
33	13-19	30.4	33.6	23.0	23.6	4.0	6.9	12.4	9.5	87	89	67	46	4.5	7.1	35.9	6.9	425.4	2.0	2.0
34	20-26	30.4	33.8	22.8	23.6	4.1	5.6	11.9	1.9	87	92	67	57	4.3	4.1	42.5	28.9	454.3	1.9	4.0
35	27-2 Sep	30.5	29.1	22.7	22.4	4.2	2.1	9.3	4.1	87	94	66	81	4.6	5.0	42.4	73.6	527.9	2.1	5.0
36	3-9	31.0	28.8	22.5	22.7	5.3	3.3	8.6	8.7	87	93	62	65	5.3	7.0	33.6	109.2	637.1	1.5	3.0
37	10-16	32.1	30.3	22.4	22.6	6.6	4.2	8.0	7.3	85	88	57	65	5.1	5.7	22.0	0.7	637.8	1.1	0.0
38	17-23	32.9	32.5	22.4	23.1	6.8	6.0	6.4	6.4	84	90	55	56	5.2	5.2	23.7	0.5	638.3	1.4	0.0
39	24-30	33.5	34.5	22.1	20.7	7.3	8.5	5.1	1.0	84	81	50	37	5.0	4.2	24.4	2.0	640.3	1.4	0.0
40	1-7 Oct	33.7	36.5	21.2	21.1	7.6	7.4	4.8	1.4	82	73	47	29	5.4	5.2	23.4	0.0	640.3	1.1	0.0
41	8-14	34.0	36.8	19.8	20.9	8.1	5.6	4.5	1.7	78	66	40	26	5.3	5.4	13.1	0.0	640.3	0.7	0.0
42	15-21	33.7	34.5	18.3	21.8	8.2	5.6	4.6	1.4	76	76	37	37	5.3	5.6	6.1	0.0	640.3	0.4	0.0
43	22-28	33.1	31.9	16.8	18.0	8.3	4.3	4.4	1.1	74	77	34	37	5.3	4.0	7.6	0.0	640.3	0.4	0.0
44	29-4 Nov	32.7	33.8	16.0	15.9	8.4	7.9	4.1	1.3	73	68	32	21	5.3	4.7	2.3	0.0	640.3	0.2	0.0
45	5-11	32.3	33.5	15.2	16.6	8.4	6.5	3.9	1.4	71	69	32	28	5.1	5.2	3.0	0.0	640.3	0.2	0.0
46	12-18	31.6	30.0	14.6	20.4	8.3	3.2	3.9	2.2	73	87	32	46	4.8	3.5	5.3	20.1	660.4	0.2	2.0
47	19-25	31.0	31.7	13.3	12.9	8.4	7.4	3.7	0.9	72	72	30	16	4.6	4.2	7.7	0.0	660.4	0.3	0.0
48	26-2 Dec	30.5	32.2	12.8	12.4	8.4	7.2	3.6	0.6	71	75	32	15	4.4	3.6	5.5	0.0	660.4	0.3	0.0
49	3-9	30.0	30.8	11.9	10.9	8.4	8.3	3.8	0.9	71	73	30	18	4.3	4.4	1.0	0.0	660.4	0.1	0.0
50	10-16	29.6	29.5	10.9	14.4	8.4	4.7	3.6	1.5	71	74	28	33	4.2	4.6	0.8	0.9	661.3	0.1	0.0
51	17-23	29.5	26.4	10.8	6.9	8.5	8.3	3.8	1.6	70	71	29	16	4.1	5.0	0.9	0.0	661.3	0.1	0.0
52	24-31	29.1	28.6	11.1	8.3	8.3	8.6	4.5	1.5	71	69	30	16	4.2	5.2	2.6	0.0	661.3	0.2	0.0
	Weekly Weather data for the year 2015																			
1	1-7 Jan	28.8	23.7	11.0	13.4	8.2	4.2	4.4	1.1	71	88	31	49	4.2	3.3	2.8	51.4	51.4	0.2	2.0
2	8-14	29.3	26.9	11.7	7.0	8.3	9.1	4.4	0.7	71	81	30	14	4.4	4.0	3.3	0.0	51.4	0.2	0.0

During the crop growing season, the maximum temperature was 34.0^{0}C during **41th** MW. The minimum temperature was 6.9 ^{0}C during 51th MW.

Bright sunshine hours were mostly lower during 35th MW, and higher (8.6 hrs.) during 52th MW than normal (8.4 hrs.) by 0.5 hours, The bright sunshine hours were lower than normal and helped the crop to utilize the available soil moisture for comparatively larger period of time.

Wind speed was lower than normal throughout growing season which has helped to keep the rate of evaporation lower and remained favorable for the crop.

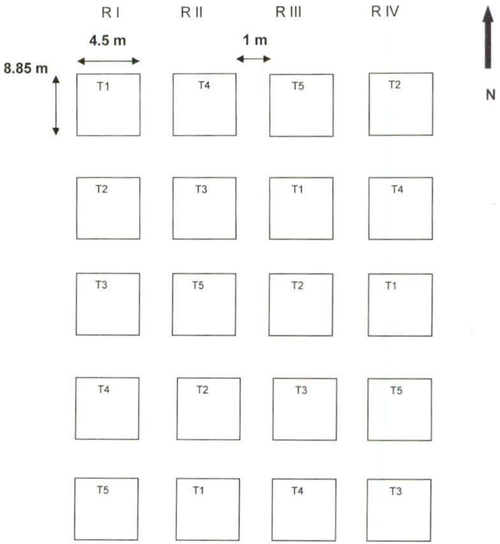
3.3: Soil characteristics of experimental site

The experimental site was fairly leveled and uniform in depth and topography. In order to know the soil fertility status of the experimental site, the soil samples from 15 to 30 cm depth were randomly collected from different locations of the experimental field before the start of the experiment and a composite sample was prepared and analyzed for various soil properties. The methods adopted to determine the important initial properties and data pertaining to them are presented in Table 2.

3.4: Experimental details

3.4.1 Experimental design and layout

The experiment was laid out in Randomized Block Design with five treatments each replicated four times. The treatments were allotted randomly in each replication. The gross plot size was 4.5 m x 8.85 m. The net plot size was 3.6 m x 5.85 m. Details of the treatments along with symbols used in plan of layout are given in Fig. 1



Plot size - Gross – 4.5 m x 8.85 m

Net – 3.6 m x 5.85 m

Fig. 1: Layout of experimental plot

3.4.2 Other details

1	Crop	:	Pearl millet (*Pennisetum glaucum* (L))
2	Variety	:	ICTP-8203
3	Experimental design	:	Randomized Block Design
4	Number of replications	:	4
5	Number of treatments	:	5
6	Total number of plots	:	20
7	Plot size	:	Gross - 4.5 m x 8.85 m
			Net - 3.6 m x 5.85 m
8	Date of sowing	:	21st Aug 2014
9	Spacing	:	45 cm x 15 cm
10	Seed rate	:	4 kg ha^{-1}
11	Fertilizer dose	:	As per treatment.
12	Sowing method	:	Dibbling
13	Season	:	*Kharif* 2014

3.5: Treatments details

Sr. No.	Treatments
T_1	Absolute control (No fertilizer)
T_2	RDF (60:30:00 N, P_2O_5 and K_2O kg ha^{-1})
T_3	RDF + 15 kg K_2O ha^{-1}
T_4	RDF + 30 kg K_2O ha^{-1}
T_5	RDF + 45 kg K_2O ha^{-1}

3.6. Cultural operations

The schedule of various field operations carried out during the period of experimentation.

3.6.1 Land preparation

To obtain fine seed bed, ploughing was done up to 30 cm depth using tractor drawn plough followed by harrowing for clod crushing and removing the stubbles of previous crop and weeds. Stubbles were picked to clean the field. The experiment was laid out as per plan of layout (Fig.1.).

3.6.2 Seeds and sowing

Certified seed of pearl millet, variety ICTP-8203 with the seed rate 4 kg ha^{-1}. The sowing was undertaken after receipt of sufficient rains by dibbling method keeping 45 cm distance between two rows while plant to plant distance maintained was 10 cm.

3.6.3 Thining and gap filling

After one week of sowing, gaps were filled wherever necessary in the pearl millet crop. Thinning was done after 09 days of sowing and single plant was retained per hill at distance of 15 cm to maintain required plant population.

3.6.4 Fertilizer application

The fertilizers were applied as per treatments. The recommended dose of fertilizer (60:30:00 NPK kg ha^{-1}) was applied through urea (46% N) and single super phosphate (16% P_2O_5) and muriate of potash (60% K_2O).

3.6.5 Harvesting and threshing

Harvesting was done manually when the crop showed physiological maturity and the grains were completely matured. The harvesting was done by cutting the earhead. Border rows were harvested and kept separately and then crop from each net plot area was harvested separately. The harvested produce from each net plot was collected in different bags as per treatment. Observation plants were harvested separately and were taken to the laboratory for post harvest studies. After sun drying the produce from each net plot was threshed manually and clean seeds were obtained by winnowing.

3.7: Quality parameters

Five plants were randomly selected from each net plot treatment wise from all the replications. The plants were labeled and various quality parameters were recorded on these plants periodically after 20 days of interval till maturity of the crop. Observations on yield components were recorded after harvest of crop.

Various quality parameters recorded during the period of investigation.

3.8. Chemical studies

3.8.1 Soil analysis

Composite soil sample 0-30 cm depth from randomly selected spots in the experimental area was collected before start of experiment. It was air dried in shade, grinded and analyzed for determination of physical and chemical properties of soil.

Treatment wise soil sample 0-15 cm depth from each plot were collected after harvesting of crop. The samples were air dried, grinded and analyzed for estimation of available nitrogen, phosphorous and potassium. Balance sheet of N, P_2O_5 and K_2O was worked by considering initial fertility status and final balance of nutrients in the soil after completion of experimentation. The method adopted for these studies are given below.

3.8.2 Soil pH

Soil pH was determined by using Systronics glass electrode pH meter using 1:2.5 soil water suspensions (Jackson, 1967).

3.8.3 Organic carbon (g kg^{-1})

It was determined by Walkley and Blacks method as described by Jackson (1973).

3.8.4 Available nitrogen (kg ha^{-1})

The available nitrogen from soil was estimated by alkaline permanganate method as described by Subbiah and Asija, (1956).

3.8.5 Available phosphorus (kg ha^{-1})

It was determined by Olsen's method using 0.5 M sodium bicarbonate ($NaHCO_3$), pH 8.5 as extractant.Darco-G-60 soluble phosphorus was used to absorb the dispersed organic matter and make the filtrate colourless for further colorimetric analysis (Watanabe and Olsen,1965).

3.8.6 Available potassium (kg ha^{-1})

It was determined by Flame photometer using Ammonium acetate (p^H 7.0) as an extractant as described by Hanway and Heidel (1952).

3.9 Nutrient uptake

Nutrient uptake of nitrogen, phosphorous and potassium was calculated by multiplying the per cent N, P and K content with corresponding grain and straw yields of each treatment.

3.9.1 Total nitrogen (kg ha^{-1})

Total nitrogen in plant samples was determined by Kjeldahl method in which complex nitrogenous compounds in plant samples were converted into ammonia and then to ammonium sulphate. The ammonia in the ammonium sulphate is released with NaOH during distillation and absorbed in a known volume of standard sulphuric acid. The unutilized excess of standard H_2SO_4 is determined by a back titration with standard sodium hydroxide. The total nitrogen is then calculated from amount of the standard H_2SO_4 neutralized by absorbed ammonia during distillation (Jackson, 1967).

Digestion of sample

For the nutrients other than nitrogen, the plant material was digested in a di-acid 9:4 HNO_3: $HClO_4$. The samples were predigested with 25 ml HNO_3 $gram^{-1}$ sample to avoid explosion. Volume was made up with deionized water and the aliquots of this solution were used for the determination of P and K.

3.9.2 Total phosphorus

Total phosphorous in the extract was estimated by reacting the extract with vanadomolybdate forming yellow colour complex in HNO_3 medium. The colour was developed in about 30 minute and the transmittance or absorbance of solution was read at colorimeter using blue filter (Jackson, 1967).

3.9.3 Total potassium

The extract was diluted to appropriate concentration and was directly atomized to the flame photometer (Jackson, 1967).

3.10 Potassium Use Efficiency(KUE)

$$KUE = \frac{\text{(yield obtained in K fertilizer treatment)} - \text{(yield obtained in } K_2O \text{ fertilizer treatment)}}{K_2O \text{ applied kg}}$$

3.10 Statistical analysis

The data collected during the course of present investigation were statistically analyzed by adopting standard methods known as 'Analysis of Variance' (Panse and Sukhatme, 1967). Where ever results were significant critical differences (CD) were worked out at 5 per cent level of probability for comparison of treatment mean. The treatment effects were presented by making tables of means with appropriate standard error (SE m ±) and CD value.

CHAPTER IV

RESULTS AND DISCUSSION

An experiment entitled "Effect of potassium on soil fertility, nutrient uptake, yield and quality of pearl millet in Inceptisol" was conducted during *kharif* season of 2014-15 at the Research Farm , Department of Soil Science and Agricultural Chemistry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola.

During the course of field experimentation, the observations recorded on yield, nutrient uptake, quality and soil fertility of pearl millet as influenced by different treatments are presented in this chapter under appropriate heads.

4.1:Effect of potassium fertilization on Yield

4.1.1:Grain yield

4.1.2 :Straw yield

4.2: Effect of potassium fertilization on Nutrient uptake

4.2.1:Nitrogen uptake

4.2.2:Phosphours uptake

4.2.3:Potassium uptake

4.3: Effect of potassium fertilization on Quality parameters

4.3.1:Ash content

4.3.2:Crude protein

4.3.3:Starch content

4.3.4:Test weight

4.4: Effect of potassium fertilization on Soil fertility status

4.4.1:Fertility status of experimental soil at the start of experiment

4.4.2:pH,EC and Organic carbon content

4.4.3:Available Nitrogen

4.4.4:Available Phosphours

4.4.5:Available Potassium

4.1: Effect of potassium fertilization on Yield

4.1.1: Grain yield

The data pertaining to the grain yield of pearl millet is presented Table 1.

The grain yield of pearl millet ranged from 7.07 to 16.90 q ha^{-1}. Significantly highest grain yield of 16.90 q ha^{-1} was registered with RDF+45kg K_2O ha^{-1}.However, the grain yield (16.60 q ha^{-1}) received from the treatment T4,where the recommended dose of NPK (60:30:00),were applied with 30 kg K_2O ha^{-1}were found at par with T5(16.90 q ha^{-1}).

Grain yield of pearl millet obtained with lower dose of K_2O i.e. 15 kg K_2O ha^{-1} along with RDF (13.80 q ha^{-1}) was significantly lower than the grain yield received by the treatment T4 and T5(16.60qha^{-1} and 16.90 q ha^{-1} respectively).Similar trend in the grain yield were also noted where only RDF i.e. 60:30:00 kg NPK ha^{-1}(12.81 q ha^{-1}) was given to the pearl millet. The grain yield were significantly reduced as the fertilizer K_2O dose were reduced from 45 kg K_2O ha^{-1} to no K_2O application.However,the grain yield received from the treatments T2 and T3 were found statistically at par. Significantly lowest grain yield was recorded in the treatment where no fertilizers were applied(T1).

Similar trend was also reported by Marschner (1995)and Yadav et al.(2011).

4.1.2 : Straw yield

The data pertaining to the straw yield of pearl millet is presented Table 1.

The Straw yield of pearl millet ranged from 17.65 to 35.91 q ha^{-1} significantly highest straw yield (35.91 q ha^{-1}) was noted in the treatment of application of RDF (60:30:00kg NPK ha^{-1}) +45kg K_2O ha^{-1}(T5). However, the straw yield recorded in the treatment of application of RDF+30kg K_2O ha^{-1} i.e. T4(35.60 q ha^{-1})were found statistically at par with treatment T5.

Application of potassium in the tune of 15 kg K_2O ha^{-1} along with RDF i.e. T3 (30.48 q ha^{-1}) reported significantly lower straw yield as compaired to T4 and T5.

Significantly lowest straw yield (1765 q ha^{-1}) was noted in the control treatment (T1).

These results are in conformity with Marschner (1995), Almodares (2008), Yadav *et al.* (2011) and Singh and Majumdar (2012).

Table 1. Grain yield and straw yield of pearl millet as influenced by various treatments

Sr. No.	Treatments	Grain Yield (q ha^{-1})	Straw Yield (q ha^{-1})	KUE (kg kg^{-1})
1)	T1-Control	7.07	17.65	-
2)	T2-RDF(60:30:00)	12.81	28.83	-
3)	T3-RDF+ 15kg K_2O ha^{-1}	13.80	30.48	6.6
4)	T4-RDF+30 kg K_2O ha^{-1}	16.60	35.60	12.63
5)	T5-RDF+45 kg K_2O ha^{-1}	16.90	35.91	9.08
	SE(m)$\pm$	0.86	1.50	
	CD (5%)	0.258	4.512	

4.2: Effect of potassium fertilization on Nutrient uptake

The effect of potassium fertilization on nutrient uptake as influenced by various treatments is presented in Table 2.

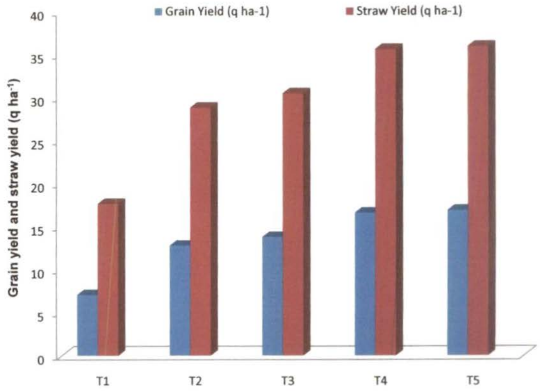


Fig. 1 Grain yield and straw yield of pearl millet as influenced by various treatments

4.2.1 Nitrogen uptake (kg ha^{-1})

The total uptake of nitrogen was increased and varies significantly .The nitrogen uptake varies from 20.08 to 58.20 kg ha^{-1}. The application of graded levels of K_2O as compared to RDF significantly influenced the uptake of nitrogen. Treatment receiving RDF+45 kg K_2O ha^{-1} recorded highest total N in the plant to the tune of 58.20 kg ha^{-1}. It was followed by RDF+30 kg K_2O ha^{-1} with an uptake of nitrogen 56.55 kg ha^{-1} .However,the nitrogen uptake by treatment T4 i.e. RDF + 30 kg K_2O ha^{-1}(56.55 kg ha^{-1})was found statistically at par with treatment T5 (58.20 kg ha^{-1}),where the fertilizer K was applied upto 45 kg K_2O ha^{-1} along with RDF.

The nitrogen uptake recorded by the treatment of application of RDF i.e. T2 (48.50 kg ha^{-1}) and application of RDF along with 15 kg K_2O ha^{-1} i.e. T3 (49.88 kgha^{-1}) were found at par with each other. The increase in nitrogen uptake by treatment receiving 45 and 30 kg K_2O was found to an extent of 20 and 17 %, respectively over the RDF. Significantly lower nitrogen uptake was recrded in the control treatment i.e. T1 (20.08 kg ha^{-1}). This increase application of fertilizer K_2O reflected on the increased uptake of nitrogen of pearl millet.

This behaviour specifies that plant requires adequate supply of K_2O for absorbing NO_3-N and maintaining high level of nitrate reductase activity. Similar result recorded by Ali *et al.* (1991).

4.2.2 Phosphorus uptake (kg ha^{-1})

The phosphours uptake ranged from 4.52 to 14.02 kg ha^{-1}.The phosphours uptake by pearl millet were significantly higher in all the treatments over control. However, the phosphorous uptake recorded in the treatment T2(12.78 kg ha^{-1}),T3(13.25 kg ha^{-1}),T4(13.92 kg ha^{-1}) and T5(14.02 kg ha^{-1}) were found statistically at par with each other. Significantly lower phosphours uptake was reported where no fertilizers were applied i.e. T1 (4.52 kg ha^{-1}).

As RDF and other K_2O treatments recorded non-significant difference in uptake of phosphorus, it point out that there did not exist any direct correlation of K_2O over the uptake of phosphorus, even when K is present in abundance. These results are in conformity with Anand Swarup (1995).

4.2.3 Potassium uptake (kg ha^{-1})

Uptake of K_2O significantly increased with the application of higher doses of potassium i.e. with RDF+45 kg K_2O ha^{-1} and RDF+30 kg K_2O ha^{-1} to an extent of 59.43 and 57.19 kg ha^{-1}. The added uptake of potassium over RDF by these two treatments was increased to the tune of 45.4 and 39%,however they were found at par with each other.When the potassium fertilization were applied at the rate of 15 kg K_2O ha^{-1} along with RDF there was significantly increased in K uptake over RDF treatment. As the dose of fertilizer K increased the from 15 to 45 kg ha^{-1} and also the uptake of K also increased.

Application of higher level of K_2O to pearl millet resulted in significantly increase in total K_2O uptake. K_2O actives plant enzymes functioning in the ammonium assimilation and transport of amino acids. The highest total uptake of K_2O in treatment receiving RDF+45 kg K_2O ha^{-1}, therefore, may be attributed to higher available K_2O status at the exchangeable and non-exchangeable sites, high cation-exchange capacity of the soil, ensuing sufficient availability of K_2O at soil-root interphase. Similar results were reported by Tamboli *et al.* (2012).

There are evidences that, more than half of exchangeable K_2O towards the crop uptake is mostly contributed from the soil depth below 15 cm. In case of treatment RDF+45 kg K_2O ha^{-1} and RDF+30 kg K_2O ha^{-1}, in this context, it is to point out that, there was a better root growth with RDF+45 kg K_2O ha^{-1} and RDF+30 kg K_2O ha^{-1} as compared to other treatments; resulting in additional absorption of exchangeable K_2O from the greater soil depth. Tondon and Sekhon (1988), Srinivasa Rao (2013) also reported the similar results. With addition of K_2O as an inorganic fertilizer, especially under *Vertisol* condition, in-solution and exchangeable K_2O are readily taken up by the roots from the soil solution. Hence under treatments RDF+45 kg K_2O ha^{-1} and RDF+30 kg K_2O ha^{-1}, due to addition of adequate amount of K_2O to the soil, there might have higher uptake by the plant with these two treatments. Significantly lower K_2O uptake was recrded in control treatment.

Table 2.Total Nutrient uptake (kg ha^{-1}) as influenced by various fertilizer treatments

Treatments	Total Nutrient uptake (kg ha^{-1})		
	Nitrogen	Phosphorus	Potassium
T- Control	20.08	4.52	25.43
T_2- RDF(60:30:00)	48.50	12.78	49.41
T_3- RDF+15 kg K_2O ha^{-1}	49.88	13.25	52.21
T_4- RDF+30 kg K_2O ha^{-1}	56.55	13.92	57.19
T_5- RDF+45 kg K_2O ha^{-1}	58.20	14.02	59.43
SE(m)±	1.71	0.81	0.75
CD (5%)	5.18	2.61	2.30

4.3: Effect of potassium fertilization on Quality parameters

Table 3. Quality parameter as influenced by various fertilizer treatments after harvest of pearlmillet

Sr. No.	Treatment	Ash content (%)	Crude protein (%)
1	T1-Control	0.3	6.70
2	T2-RDF(60:30:00)	0.5	7.53
3	T3-RDF+15kg K_2O ha^{-1}	0.8	9.12
4	T4-RDF+30kg K_2O ha^{-1}	1.1	9.60
5	T5-RDF+45kg K_2O ha^{-1}	1.3	10.65

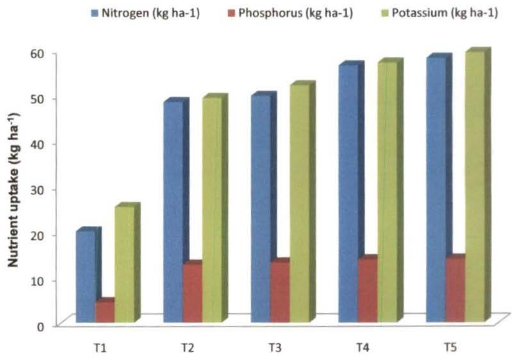


Fig. 2 Nutrient uptake (kg ha^{-1}) as influenced by various fertilizer treatments

Sr. No.	Treatment	Starch content (%)	Test weight (g)
1	T1-Control	56	11.24
2	T2-RDF(60:30:00)	58	12.93
3	T3-RDF+15kg K_2O ha^{-1}	59	12.95
4	T4-RDF+30kg K_2O ha^{-1}	61	12.99
5	T5-RDF+45kg K_2O ha^{-1}	65	13.07

4.3.1: Effect of potassium fertilization on Ash content

The data pertaining to the ash content of pearl millet in presented Table 3.

The highest ash content (1.3 %) was recorded in the treatment where recommended dose of fertilizer (60:30:00 kg NPK ha^{-1}) were combined with 45 kg K_2O ha^{-1} i.e.T5,followed by the treatment of application of RDF + 30 kg K_2O ha^{-1} i.e. T4 (1.1%)

The lowest ash content was noted in control treatment where no fertilizers were applied. As the potassium fertilization increased from 0 to 45 kg K_2O the ash content were also increased with the increament of potassium application.

Similar trend of ash content was also reported by Abdulla *et al.* (1998) and Singh *et al.* (2010).

4:3:2: Effect of potassium fertilization on Crude protein

The data pertaining to the crude protein of pearl millet is presented in Table 3.

The highest crude protein (10.65 %) was noted in the treatment where recommended dose of fertilizer (60:30:00 kg NPK ha^{-1}) were together with 45 kg K_2O ha^{-1} i.e.T5, followed by the treatment of application of RDF (60:30:00) + 30 kg K_2O ha^{-1} i.e. T4 (9.60%)

The lowest crude protein was reported in control treatment where no fertilizers were applied. As the potassium fertilization increased from 0 to 45 kg K_2O the crude protein were also increased with the increased potassium application.

Similar trends of crude protein was also noted by Selma *et al.* (2001) and Kharade *et al.* (2010).

4:3:3: Effect of potassium fertilization on Stach content

The data pertaining to the starch content of pearl millet is presented in Table 3.

The highest starch content (65 %) was recorded in the treatment where recommended dose of fertilizer (60:30:00 kg NPK ha^{-1}) were combined with 45 kg K_2O ha^{-1} i.e.T5,followed by the treatment of application of RDF + 30 kg K_2O ha^{-1} i.e. T4 (61%).However the starch content were reduced numerically as the potassium application was reduced.

The lowest starch content was noted in control treatment where no fertilizers were applied. As the potassium fertilization increased from 0 to 45 kg K_2O the starch content were also increased with the increased potassium application.

Similar trend of starch content was also reported by Abdalla *et al.* (1998) and Kharade *et al.* (2010).

4:3:4: Effect of potassium fertilization on Test weight

The data pertaining to the test weight of pearl millet is presented in Table 3.

The highest test weight (13.07 g) was noted in the treatment where recommended dose of fertilizer (60:30:00 kg NPK ha^{-1}) with 45 kg K_2O ha^{-1} i.e.T5,followed by the treatment of application of RDF (60:30:00) + 30 kg K_2O ha^{-1} i.e. T4 (12.99 g)

The lowest test weight was reported in control treatment where no fertilizers were applied. As the potassium fertilization increased from 0 to 45 kg K_2O the test weight were also increased with the increased potassium application

Similar findings were also reported by , Sarma (1993), Brar *et al.* (2007), Khushwaha *et al.* (2007), Yadav (2007) Paramasivan *et al.* (2012) and Yadav (2012).

4.4: Effect of potassium fertilization on Soil fertility status

4.4.1Fertility status of experimental soil at the start of experiment

Table 4. Physical and chemical properties of experimental soil at the start of experiment (*kharif,* 2012-13)

Sr. No.	Soil properties	Value
1	pH	8.17
2	EC dSm^{-1}	0.28
3	Organic Carbon,g kg^{-1}	4.82
4	Available N, kg ha^{-1}	151.1
5	Available P, kg ha^{-1}	12.88
6	Available K,kg ha^{-1}	307

The fertility status of the experimental site at the start of experiment i.e. during 2012-2013 in presented in Table 4.

As per the values of various parameter the experimental soil was slightly alkaline in nature with 8.17 pH.The electrical conductivity was 0.28 dSm^{-1}.Organic carbon content of the soil was in the low range,with 4.82 g kg^{-1}.Available nitrogen and phosphours were in the low range with 151.1 kg ha^{-1} and 12.88 kg ha^{-1} respectively, Where as available potassium content was in moderately high with 307 kg ha^{-1}.

4.4.2:pH,EC and Organic carbon content

The data presented in Table 4 indicates that the pH values after harvest of pearl millet shows the differences in pH values ranged from (8.18 to 8.20). However, there were no significant change in pH was recorded in all the treatments. The lower value of pH 8.18 was noticed in the treatment of control (T_1) .The highest value of pH 8.20 was noticed in the treatment of application of RDF(60:30:00) + 45 kg K_2O ha^{-1}.

The mean values of EC also change within the various treatments. EC values ranged from (0.29-0.31 dSm^{-1}). The higher value of (EC 0.33 dSm^{-1}) was observed in the treatment (T_4)RDF(60:30:00) + 30 kg K_2O ha^{-1}. However, statistically there were no significant change in soil electrical conductivity in all the treatments. The findings on pH and EC values are in conformity with Muneshwar Singh (2006).

Table 5: Effect of various treatments on chemical properties of soil after harvest of Pearlmillet

Sr.No.	Treatments	pH	EC (dSm^{-1})	OC (g kg^{-1})
T_1	control	8.18	0.29	4.84
T_2	RDF(60:30:00)	8.19	0.31	4.96
T_3	T_3-RDF+15 kg K_2O ha^{-1}	8.20	0.32	5.06
T_4	T_4-RDF+30 kg K_2O ha^{-1}	8.18	0.33	5.16
T_5	T_5-RDF+45 kg K_2O ha^{-1}	8.20	0.31	5.20
	SE(m)$\pm$	**0.059**	**0.018**	**0.046**
	CD at 5%	NS	NS	NS
Intial status (2012-13)		8.17	0.28	4.82

However, data revealed in above Table 5 shows the organic carbon status after harvest of soybean ranged between (4.84 to 5.20 g kg^{-1}). The highest soil organic matter content was recorded in the treatment of RDF+ 45 kg K_2O ha^{-1} (5.20) (T_5), it was at par with the treatment where RDF+ 30 kg K_2O ha^{-1} (5.16)(T_4). Lowest organic carbon status were recorded in the control treatment. Numerical increase in organic carbon content the treatments were recorded with the treatment of potassium from 00 to 45 kg ha^{-1} along with RDF. However, statistically the results were non significant.

The similar findings were observed by Singh *et al.* (2005) Kundu (2008), Yang *et al.* (2007), and Subehia *et al.* (2013).

4.4.2: Available Nitrogen

The data in respect to final status of available nitrogen is presented in Table 6 and graphically represented in Fig 3.

Table 6. Available nutrient status (kg ha^{-1}) in soil after harvest of pearl millet by under various treatments.

	Avaiable Nutrients (kg ha^{-1})		
Treatments	**Available N**	**Available P**	**Available K**
T1- Control	150.1	12.25	305
T2-RDF (60:30:00)	211.8	16.35	307
T3-RDF+15 kg K_2O ha^{-1}	213.1	16.65	353
T4-RDF+30 kg K_2O ha^{-1}	214.8	17.10	370
T5-RDF+45 kg K_2O ha^{-1}	216.1	17.45	382
SE(m)$\pm$	**5.49**	**0.72**	**3.68**
CD at 5%	**16.52**	**2.12**	**8.24**
Intial status	151.1	12.88	307

Application of potassium significantly increases available nitrogen in soil after harvest of pearl millet. The highest available nitrogen

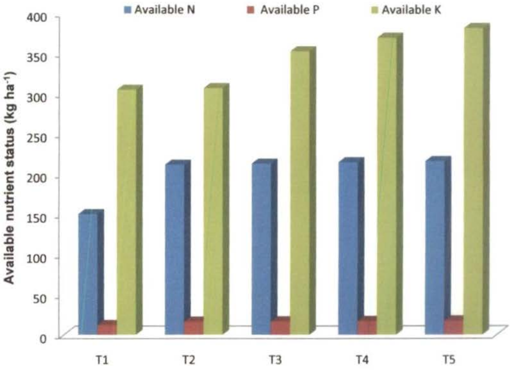


Fig. 3 Available nutrient status (kg ha^{-1}) in soil after harvest of pearl millet by under various treatments.

was (216.1 kg N ha^{-1}) was observed in treatment T5 (RDF + 45 kg K_2O ha^{-1}) and found to be significantly at par with treatment T4 (RDF + 30 kg K_2O ha^{-1}) which obtained 214.8 kg N ha^{-1}. Also the treatment T3 (RDF + 15 kg K_2O ha^{-1}) was recorded 213.1 kg N ha^{-1} and it was at par with treatment T2 (RDF 60:30:00) obtained 211.8 kg N ha^{-1}. The lowest available nitrogen was (150.1 kg N ha $^{-1}$) was obtained in treatment T1 .i.e. control.While all treatments significantly superior over control treatments.The available nitrogen status after harvest of the crop was numerically increased as the dose of potassium were increased from 00 to 45 kg ha^{-1}. Similar results report of soil available nitrogen were also reported by Srinivasa Rao (2013), Ali *et al.* (1991) .

4.4.2: Available Phosphorus

The results regarding final status of available phosphorus are presented in Table 6 and graphically represented in Fig 3.

The available phosphours content of the soil was in the range of 12.25 to 17.45 kg P ha^{-1}. Application of potassium significantly increases available phosphours in soil after harvest of pearl millet. The highest available phosphours was (17.45 kg P ha^{-1}) was observed in treatment T5 (RDF + 45 kg K_2O ha^{-1}) and found to be significantly at par with treatment T4 (RDF + 30 kg K_2O ha^{-1}) which obtained 17.10 kg P ha^{-1}. Also the treatment T3 (RDF + 15 kg K_2O ha^{-1}) was recorded 16.65 kg P ha^{-1} and it was at par with treatment T2 (RDF 60:30:00) obtained 16.35 kg P ha^{-1}. The lowest available phosphours (12.25 kg P ha $^{-1}$) was obtained in treatment T1 .i.e. control.While all treatments significantly superior over control treatments. Similar findings were recorded by , Paramasivan (2012) and Singh (2012). From the data, it can inferred that addition of K_2O certainly helps in improving the available phosphorus status under pearl millet cropping system.

4.4.3: Available Potassium

The values of final status of available potassium are presented in Table 6 and graphically represented in Fig 3.

It is indicative from the data that the addition of graded levels of K increased the availability of K and improved the soil fertility status even after high uptake by the crop. Application of potassium significantly increases available potassium in soil after harvest of pearl millet. The highest available potassium was (382 kg K_2O ha^{-1}) was observed in treatment T5 (RDF + 45 kg K_2O ha^{-1}) and found to be significantly at par with treatment T4 (RDF + 30 kg K_2O ha^{-1}) which obtained 370 kg K_2O ha^{-1}. Also the treatment T3 (RDF + 15 kg K_2O ha^{-1}) was recorded 353 kg K_2O ha^{-1} and it was at par with treatment T2 (RDF 60:30:00) obtained 307 kg K_2O ha^{-1}. The lowest available potassium was (305 kg N ha $^{-1}$) was obtained in treatment T1 .i.e. control. While all treatments significantly superior over control treatments.

Improvement in the soil fertility status due to RDF+45 kg K_2O ha^{-1} may be attributed to release of K_2O from the less accessible sources including the non exchangeable fraction. This K_2O release was improved by higher uptake of exchangeable K_2O by the plant roots thus the soil having low K_2O availability have the tendency to match the K_2O demand of crop which is fulfilled by quantity of non exchangeable K_2O in soil and its rate of release from the soil fraction. Further, water soluble K_2O being a readily available source of K_2O, may be subjected to change either under cropping or external K_2O supply. This form of K_2O is in dynamic equilibrium with exchangeable K_2O and whatever change induced by crop removal of K_2O, is compensated by the release of exchangeable K_2O into solution. Hence, it can be presumed that; though the *vertisols* are supposed to be rich in available K_2O, can also respond to added K_2O up to 45 kg ha^{-1}. Similar results were reported by Shrinivsa rao (2013), Yadav (2008), Paramasivan (2012).

CHAPTER V

SUMMARY AND CONCLUSIONS

A field investigation entitled "Effect of potassium on soil fertility, nutrient uptake, yield and quality of pearl millet in inceptisol" was carried out on Reserch Farm, Department of Soil Science and Agricultural Chemistry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. (Maharashtra) to find out effect of graded levels of potash to pearl millet on its soil fertility, nutrient uptake, yield and quality status, under ranifed condition during *kharif* season of 2014-15.

Five treatments with various combinations of fertilizer were compared with each other in Randomised Block Design with four replications. The treatments were-1)control(no fertilizer), 2)RDF (recommended dose of fertilizer, 60:30:00 kg NPK ha^{-1}), 3)RDF+15kg K_2O ha^{-1} (60:30:00 + 15 kg K_2O ha^{-1}), 4)RDF+30kg K_2O ha^{-1} (60:30:00 + 30 kg K_2O ha^{-1}), 5)RDF+45kg K_2O ha^{-1} (60:30:00 + 45 kg K_2O ha^{-1}). Treatments were compared to evaluate the effect of different fertilizer levels on soil fertlity, nutrient uptake ,yield and quality of pearl millet.

The soil of experimental field was fairly leveled and uniform in moderately high in available nitrogen (192.3 kg ha^{-1}), moderate in available phosphorus (16.9), rich in available potassium (340 kg ha^{-1}) with slightly alkaline in reaction. The crop was sown on 21th Aug, 2014. Fertilizer application to the crop was made as per the treatments. Crop was harvested on 27th Nov, 2014.

5.1. Effect of potassium fertilization on Yield

Significantly highest grain yield (16.90q ha^{-1}), stover yield (35.91q ha^{-1}) was registered with RDF+45 kg K_2O ha^{-1}. The followed by treatment was RDF+30 kg K_2O ha^{-1}. Statistically there were no differences between the values obtained with these two treatments. Treatments RDF and RDF+15 kg K_2O ha^{-1} also found similar with each other. The lowest value for grain yield (7.07q ha^{-1}), stover yield (17.65q ha^{-1}) was registered with treatment control i.e.(T1).

5.2. Effect of potassium fertilization on Nutrient uptake

Treatment receiving 45 kg K_2O ha^{-1} recorded highest total N in the plant. It was followed by treatment RDF+30kg K_2O ha^{-1}. This increase in nitrogen uptake by treatment receiving 45 and 30 kg K_2O was found to an extent of 20 and 17%, respectively over the RDF.

The non significant differences by various fertilizer treatments, including RDF and other K_2O treatments were obtained for total phosphorus uptake by the plant. Numerically higher values for uptake of phosphorus were obtained with RDF+45kg K_2O ha^{-1} and RDF+30kg K_2O ha^{-1}.

Uptake of K_2O significantly increased with the application of higher doses of potassium i.e. with RDF+45kg K ha^{-1} and RDF30+kg K_2O ha^{-1}.

5.3. Effect of potassium fertilization on Quality parameters

The highest ash content, crude protein, starch content and test weight was recorded in treatment RDF + 45 kg K_2O ha^{-1} and the lowest ash content, crude protein, starch content and test weight was observed in treatment control i.e. (T1).

5.4 Effect of potassium fertilization on Soil fertility status

There was a gain of nitrogen after completion of crop cycle with RDF+45 kg K_2O ha^{-1}. It was followed by treatment RDF+30 kg K_2O ha^{-1}. Treatment RDF also recorded a gain of nitrogen over the initial status. Whereas, the treatment where control treatment was applied, recorded a loss of N from soil system.

There was a minor improvement in phosphorous status in soil due to varying levels of K_2O. The maximum gain of P was observed in treatment RDF+45 kg K_2O ha^{-1}. It was followed by RDF+30 kg K_2O ha^{-1}. RDF+15 kg K_2O ha^{-1} also recorded positive magnitude of available phosphorus. Treatment receiving RDF and control treatment recorded mining of available phosphorus.

The highest of K_2O was obtained with treatment RDF+45 kg K_2O ha^{-1}. The second best treatment was RDF+30 kg K_2O ha^{-1}. These two treatments were followed by RDF+15 kg K_2O ha^{-1}. Treatment where RDF was applied, found poor and recorded negative balance of available K_2O

5.5 Conclusions

From the above observations it is conclude that , significantly highest grain , straw yield ,KUE, nutrient uptake, improvement soil fertility status and quality parameters of pearl millet were recorded by the applications of RDF(60:30:00 NPK kg ha^{-1}) along with 45 kg K_2O ha^{-1}.However the grain, straw yield ,KUE, nutrient uptake, improvement soil fertility status and quality parameters were at par with RDF(60:30:00 NPK kg ha-1) along with 30 kg K_2O ha^{-1}.

CHAPTER VI

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