

**EFFECT OF MANURE AND CHEMICAL
FERTILIZER DOSES ON THE INCIDENCE
OF MAJOR PESTS OF SORGHUM**

THESIS

**Submitted to
Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola
in partial fulfilment of the requirements
for the Degree of**

**MASTER OF SCIENCE
IN
AGRICULTURE
(AGRICULTURAL ENTOMOLOGY)**

**By
THAKRE MANOJ KHANDU**

Dr. PDKV Library, Akola

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**DEPARTMENT OF AGRICULTURAL ENTOMOLOGY
POST GRADUATE INSTITUTE, AKOLA**

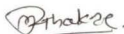
**DR. PANJABRAO DESHMUKH KRISHI VIDYAPEETH,
KRISHINAGAR PO, AKOLA (MS) 444 104**

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DECLARATION OF STUDENT

I hereby declare that the experimental work and its interpretation in the Thesis entitled "**EFFECT OF MANURE AND CHEMICAL FERTILIZER DOSES ON THE INCIDENCE OF MAJOR PESTS OF SORGHUM**" or part thereof has not 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 sources of materials used and all assistance received during the course of investigation have been duly acknowledged.



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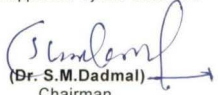
CERTIFICATE

This is to certify that the thesis entitled "EFFECT OF MANURE AND CHEMICAL FERTILIZER DOSES ON THE INCIDENCE OF MAJOR PESTS OF SORGHUM" submitted in partial fulfillment of the requirement for the degree of "Master of Science in Agriculture (Agricultural Entomology)" of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola is a record of bonafide research work carried out by **Thakre Manoj Khandu** under my guidance and supervision.

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

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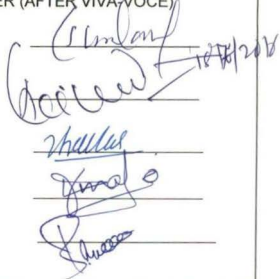

Associate Dean,

Post Graduate Institute,

Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola.

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

1. Chairman (Dr. S. M. Dadmal)
2. Member (Dr. D. B. Undirwade)
3. Member (Dr. V.U. Sonalkar)
4. Member (Dr. D. V. Mali)
5. External Member (Dr. S. K. Bhalkar)


_____ 10/5/2016

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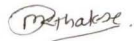
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Place: Akola

Date: 31 / 5 / 2016



(Thakre Manoj Khandu)

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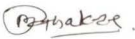
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(D)**ABBREVIATIONS**

%	-	Per cent
/	-	Per
CD	-	Critical difference
cm	-	Centimeter
CV	-	Coefficient of variation
DAE	-	Days after emergence
et al.	-	et alia (and his associates)
etc.	-	Et cetera
Fig.	-	Figure
g/gm	-	gram (s)
ha	-	Hectare
i.e.	-	id est (that is)
kg	-	kilogram
Kg/ha	-	Kilogram per hectare
Qtl/ha	-	quintal per hectare
m	-	meter
ml	-	millilitre
No.	-	Number
NS	-	Non significant
PDKV	-	Panjabrao Deshmukh Krishi Vidyapeeth
RBD	-	Randomized Block Design
SE (m) \pm	-	Standard error of mean
Sig.	-	Significant
viz.,	-	Videlicet (Namely)

(F)

THESIS ABSTRACT

- a. Title of the thesis : "EFFECT OF MANURE AND CHEMICAL FERTILIZER DOSES ON THE INCIDENT OF MAJOR PEST OF SORGHUM"
- b. Name of student : THAKRE MANOJ KHANDU
- c. Name and Address of Major Advisor : Dr. S. M. Dadmal
Associate Professor
Department of Agril. Entomology
Dr. Panjabrao Deshmukh Krishi
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- j. Signature, name and address of forwarding authority :


Head,
Department of Agricultural Entomology,
PGI, Dr. Panjabrao Deshmukh Krishi
Vidyapeeth, Akola

S. M. Dadmal
31/5/2016

ABSTRACT

The present investigation entitled "Effect of manure and chemical fertilizer doses on the incidence of major pests of sorghum" was carried out at field of National Highway Block, CRS, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during *kharif* 2015-16. The experiment

was laid in randomized block design with eleven treatments, replicated thrice.

The significantly maximum eggs on 7 DAE were observed in treatments T₆-100 % N (0.60 egg/plant) , while lowest egg laying of shoot fly was recorded in T₁₁- Control (0.27 egg/plant), followed by T₁-50 % NPK (0.27 egg/plant) and the significantly maximum eggs on 14 DAE were observed in treatments T₆-100 % N (0.93 egg/plant) , while lowest egg laying of shoot fly was recorded in T₁₁- Control (0.47 egg/plant), followed by T₉- FYM @ 10 t /ha – Before sowing (0.47 egg/plant).

The treatments viz;T₆ -100 % N (31.67%),T₃-150 % NPK (25.00%), T₅-100 % NP (15.60%) recorded maximum shoot fly dead hearts percentage at 14, 21 and 28 DAE, respectively. Whereas, minimum dead hearts incidence was noticed in treatments T₁₁ –control (10.00) ,T₁-50 % NPK (13.93), T₈- 100 % NPK + 37.5 kg sulphur / ha (14.10). Similar result was found in stem borer leaf injury on 35 DAE.

The studies on population of aphids at 28 DAE revealed maximum population were recorded in treatments T₆- 100 % N (4.13), T₃- 150 % NPK (3.67), T₇-100 % NPK + FYM @ 5t/ha (3.20), respectively. LBB population at 28 DAE revealed maximum population were recorded in treatments -100 % NPK + FYM @ 5t/ha (3.00) , T₂- 100 % NPK (2.67), T₄- 100 % NPK + 37.5 kg sulphur / ha (2.33),respectively and spider population at 28 DAE revealed maximum population in treatments -100 % NPK + FYM @ 5t/ha (2.67) , T₂- 100 % NPK (2.00), T₄- 100 % NPK + 37.5 kg sulphur / ha (2.00), respectively.

The chlorophyll content index revealed significantly higher amount in treatments T₆- 100 % N (31.18) while lower in T₁₁ –control (23.13), and T₁-50 % NPK (25.00). Whereas, significantly maximum nitrogen content was recorded in T₃-150 % NPK (2.67) and lower in T₁₁ – control (0.73) and T₁-50 % NPK (0.94). The biochemical constituent, phosphorus content revealed significantly higher amount in treatments and T₃-150 % NPK (0.64), while lower in T₁₁ –control (0.21) and T₆- 100 % N (0.28). Whereas, significantly maximum potassium content was recorded in

T₃-150 % NPK (3.07) and lower in T₁₁ –control (0.95) and T₅-100 % NP (0.96), respectively.

Correlation between chlorophyll content recorded positive and significant association with per cent of shoot fly dead heart at 28 DAE ($r=0.638^*$). Further the nitrogen content recorded positive but non significant association with per cent of shoot fly dead heart at 28 DAE ($r=0.559$). In respect to phosphorus content correlation recorded negative but weak association with per cent of shoot fly dead heart at 28 DAE ($r=-0.016$). However, correlation recorded positive but non significant in potassium content with per cent of shoot fly dead heart at 28 DAE ($r=0.048$). The results revealed that chlorophyll content recorded positive and significant association with per cent stem borer leaf injury at 28 DAE ($r=0.712^*$). Further the nitrogen content recorded positive and significant association with per cent stem borer leaf injury at 28 DAE ($r=0.667^*$). In respect with phosphorus content correlation recorded positive and significant association with per cent stem borer leaf injury at 28 DAE ($r=0.160$). However, correlation recorded positive and significant in potassium content with per cent stem borer leaf injury at 28 DAE ($r=0.103$).

Correlation between chlorophyll content recorded positive and significant association with aphids population ($r=0.744^{**}$). Further the nitrogen content recorded positive and significant association with aphids population ($r=0.704^*$). Phosphorus content correlation recorded positive but non significant association with aphids population ($r=0.281$). Whereas, potassium correlation recorded positive but poor association with aphids population ($r=0.258$).

The highest grain yield was recorded in T₇-100 % NPK + FYM @ 5t/ha (29.17 q/ha). while lowest yield was recorded in T₁₁ –control (3.44 q/ha), followed by T₆-100 % N (12.03 q/ha), T₉- FYM @ 10 t /ha – Before sowing. (14.77 q/ha). While, the highest fodder yield was recorded in T₇-100 % NPK + FYM @ 5t/ha (61.06 q/ha). Whereas, lowest yield was recorded in T₁₁ –control (6.36 q/ha), followed by T₆-100 % N (22.34 q/ha), T₁ 50% NPK (28.73 q/ha) in ascending order.

CHAPTER I

INTRODUCTION

1.1 Background Information

The word sorghum, *Sorghum bicolor* (L.) Moench has been derived from the latin word 'sorgo' which means 'rising above'. It belongs to the family poaceae subfamily anicoidae, tribe andropogoneae and sub-tribe sorghastrae (Price et al. 2005).

Sorghum is one of the most important cereal crop grown in Africa, Asia, USA, Australia and Latin America. Its importance after wheat, maize, rice and barley is because of its good adaptation to a wide range of ecological conditions, low input cultivation and diverse uses (Aruna et al. 2011). The sorghum crop has wide range of flexibility to grow in various climatic conditions of the world and hence, it is known by diverse names viz., *jowar*, *jwar*, *chulam* or *jola* in India, *guinea* corn, *kafir* corn and *dhuma* in Africa, '*kaoling*' in China and *milo* maize in America. Sorghum species are native to tropical and subtropical regions of all continents in addition to South West Pacific and Australia.

In India, sorghum is grown on an area of 7.58 million hectares with annual production of 7.18 million tonnes with 1163 kg/ha in the *kharif* and 677 kg/ha in the *rabi* season (Anonymous, 2013). The states of India where the sorghum is mainly cultivated are Maharashtra, Karnataka, Madhya Pradesh, Andhra Pradesh and Rajasthan.

In Maharashtra, it is grown on an area of 36.18 lakh hectares with a production of 30.53 lakh tonnes with a productivity of 843 kg/ha. In Vidarbha, it is grown on an area of 2.16 lakh hectares in *kharif* with a production of 2.03 lakh tonnes with a productivity of 939 kg/ha. In *rabi*, it is grown on an area of 0.36 lakh hectares with a production of 0.277 lakh tonnes with a productivity of 769 kg/ha. (Anonymous, 2014). Sorghum is used as 'health food' because of its higher dietary fiber (7.6% to 9.2%). It contains 72.6 per cent carbohydrate, 10 to 12 per cent protein, 1.6 per cent mineral matter and 1.9 per cent fat. It contains nitrogen, starch in high quantity along with copper, zinc and molybdenum (Rana et al. 1978).

There are large number of pests have been reported on sorghum in Maharashtra, out of which very few have economic status, stem borer, shoot fly are major. Other important pests are armyworm, aphids, delphacids and earhead caterpillar etc. Among the different insect pest sorghum shoot fly *Atherigona soccata* (Rondani) is one of the regular pest causing severe damage to sorghum crop in Vidarbha region by causing dead hearts in early seedling stage reducing plant population, resulting into heavy yield losses up to 75.60 per cent in grain and 68.90 per cent in fodder (Pawar et al. 1984). Kandalkar et al. (1989) reported that shoot fly is one of the major constraints in the late sown sorghum crop for grain and fodder production.

Lepidopterous stem borer are important pests in sub-Saharan Africa. Stem borers can cause severe damage at different stages in the development of cereal crops; from seedling to maturity. When infestation is severe, there is a physiological disruption of plant growth, and panicle emergence and grain formation are severely affected, resulting in reduction in kernel number. The major stem borers of sorghum and maize in southern Africa currently are the spotted stem borer *Chilo partellus* Swinhoe (Crambidae) and the African stem borer *Busseola fusca* Fuller (Noctuidae). The spatial and temporal distribution and abundance of stem borers vary among and within host plants, presumably due to variations in their suitability for oviposition and larval development; hence they exhibit different degrees of susceptibility to borer attacks (Maluleke et al. 2005).

Numerous factors enhance the insect pest problem in field either by manipulating the environment, favourable for growth, reproduction and development of insects including traditional cultural methods, unrestricted use of chemicals (insecticides) and imbalanced use of fertilizers (Karimullah et al. 1986). Nitrogen, phosphorus and potassium are fundamental nutrients for plant growth and development which play a basic role in metabolism and energy production in plants and significantly enhance the grain yield. Leaf area duration, leaf area index (LAI), and crop photosynthetic rate reduces under nitrogen stress (Ujart and Andrade, 1995), but its excessive use not only causes wastage of resources yet can also lead to pest problems by increasing the reproduction, longevity and

overall fitness of definite pests. Damage to crops by insect pests amplifies with the application of fertilizers (Setamou et al. 1995). Millet crop grown on high rates of nitrogen survives and crop damages due to increased borer population amplified as compared to low rates of nitrogen fertilizer (Tanzubil et al. 2006).

Chemical fertilizers are compounds given to plants to promote growth, and are usually applied either through the soil for uptake by plants or by foliar spray for uptake through leaves. One of the ways of increasing the nutrient status is by boosting the soil nutrient content either using organic materials such as poultry manure, animal waste, compost or inorganic fertilizers (Dauda et al. 2005).

1.2 Importance of the study

The interest in the use of organic fertilizers is increasing due to polluting effects of chemical fertilizers in the aerial and soil environment and gradual decline in the soil fertility. Thus, continuous use of synthetic fertilizers may deteriorate soil health affecting plants, human and cattle. Most of the nitrogenous fertilizers leach down to the root zone or pollute the groundwater causing certain diseases in plants and human being. The use of agrochemicals causes the degradation of cultivable land and increases agricultural pollution, hence creating the unhealthy situation. In order to balance this situation organic farming might be practice in which instead of using of chemicals, natural resources such as organic matters, minerals and microbes are used. Organic farming system relies on large- scale application of animal wastes, farm yard manure (FYM), poultry manure (PM), compost, crop residues and green manuring, etc. which are best substitute of chemicals (Ahmad et al. 2007).

Organic fertilizers affected to rice plant growth and minimized the outbreak of insect pests and diseases such as brown plant hopper, stem borer, leaf folder, blast and sheath blight. The population of insect pests as stem borer (SB), brown plant hopper (BPH) and leaf folder (LF) on the chemical fertilizer treatment exhibited the severe outbreak more than in the treatments of chicken and hog manure compost and organic fertilizer application.(Chau and Heong, 2005).

In view of above it was felt necessary to carry out the present investigation with the following objectives.

1.3 Objectives of study

1. To know the level of infestation as influenced by different doses of manure and Chemical fertilizer.
1. To record the effect on predator abundance at different doses of manure and Chemical fertilizer.

1.4 Scope and limitations of the study

Sorghum is mostly grown as rainfed (*kharif*) or on residual moisture (*rabi*) in light to medium soils. Depending upon the climatic conditions and different manure and chemical fertilizer doses, sporadic pests like shoot fly, stem borer, aphids in a region may become serious threats (Mote, 2003). Farmers are resource poor, very few farmers adopt improved / high yielding cultivars and moisture conservation practices. Bulk of the crop is covered under poor yielding local varieties and without fertilizers. Despite severe infestation by the pests, the pest control measures are seldom adopted by farmers.

Shoot fly incidence is high in the late sown crop. Shoot fly incidence causes with an average losses of 50 per cent in India (Jotwani, 1982), but the infestation at times may be over 90 per cent, (Rao and Gowda, 1967). Management strategies for control of sorghum shoot fly incidence include population dynamics, time of sowing, Normal sowing is recommended so that the available residual moisture can be utilized fully and hence reductions in shoot fly infestation. However, many times it is not possible to adhere to this period because of variability in rainfall, non availability of seeds of improved varieties / hybrids, fertilizers, sowing implements etc. in time. It causes staggered plantings which help to increase the pest incidence.

The balanced NPK fertilizer decreased the aphid population density significantly. On the contrary, plants fertilized with higher rates of nitrogen either alone or in combinations with other fertilizers depicted higher infestation of aphid in both seasons of study. Gradual increase in temperature was conducive for enhancing predator population. Increase in

aphid population in unbalanced nutrition treatments tended to decline wheat grain yield. (Liaqat et al. 2013)

1.5 Hypothesis

Keeping in view the positive effect of manure and chemical fertilizer doses to more economic returns in crop production, the present study is useful. The various doses of manure and chemical fertilizer were tested for their effect on major pest on sorghum. Thus, this research work will help to identify superior doses of manure and chemical fertilizer for higher yield with minimum infestation of pests viz; shoot fly, stem borer and aphids etc. As nutrient in host plant play an important role in harboring the pest population, survivorship of pest etc. the same concept has been utilized in this investigation by manipulating the doses of fertilizers and manures for the nutritional pest management in sorghum.

CHAPTER II

REVIEW OF LITERATURE

The present study was aimed to find out the effect of manure and chemical fertilizer doses on the incidence of major pests of sorghum. In line of research work, literature was reviewed and presented below.

Ghosh (1962) observed relationship between nitrogen application and stem borer incidence due to the higher water content in stem and leaves of plants facilitated by uptake of higher nitrogen applied. He further opined that plants with higher water content in leaves and stem are preferred for oviposition by the borer and easy to penetrate for the neonate larvae after hatching.

Emden (1966) found that there are increases in fecundity and development rates of green peach aphid, *Myzus persicae* were highly correlated to increased levels of soluble nitrogen in leaf tissue.

Saha and Saharia (1970) reported the incidence of stem borers from 8.36% in plots without nitrogen fertilizer to 20.12% in those treated with 100 Kg/ha in sorghum.

Muthuvel et al. (1977) found increases in available N content due to application of N through organic source. Amongst the fertilizers combination the NPK or NK treatment registered highest amount of available nitrogen.

Sharma and Rana (1980) reported that favorable effect of NPK fertilization on available K content. Total potassium content was greatly increased due to application of 150 % optimal NPK followed by 100 % optimal NPK + FYM.

Taley et al. (1981) studied the bionomics of *Atherigona soccata*, Rondani. A single fly on an average laid 28 eggs. The incubation period on an average was 40.21 hours. There were three larval instars. On an average the first, second and third instars of larval and pupal instars were completed in 45.06, 52.31 and 72.38 hours and 6.80 days,

respectively in Vidarbha climate. The total life cycle was completed in 17 to 37 days. The sex ratio of male and female was 1:1.4.

Balasubramanian et al. (1986) studied the effect of fertilizers on the incidence of *Atherigona soccata* and *Chilo partellus* in field trials in India. The highest infestations by the pests were recorded in plots treated with cattle manure (*A. soccata* 27.15% and *C. partellus* 30.75%), while in plots treated with K and NK, infestations by *A. soccata* were lower as well as the incidence of dead hearts and tunnelling caused by *C. partellus*. Treatments with NP also resulted in a lower percentage of tunnelling.

Weibull (1987) reported that application of nitrogen on barley increased the phloem cell sap, which proved more favorable for *Rhopalosiphum padi*. The population of *Rhopalosiphum padi* is reported to be decreased on nitrogen deficient plants

Ogunlela and Yusuf (1988) reported that potassium application increased growth and yield in grain sorghum and also a valuable nutrient in decreasing the effects of water stress for the survival of crop plants.

Kandalkar and Narkhede (1989) observed that shoot fly was one of the major constraints in the production of grain and fodder which infests sorghum crop to the extent of 97 per cent in late sown condition. The maximum avoidable losses of sorghum grain were recorded to the extent of 33.91 per cent due to shoot fly.

Katole (1989) reported avoidable losses of sorghum due to the internal feeder mainly shoot fly and stem borer to extent of 65.15 per cent in unprotected crop in Vidarbha condition which could be saved in the protected crop. Losses were progressively increased in the delayed sowings. Further he reported that shoot fly incidence was increased progressively in the same sowing upto 4th week and it was heavily increased in the fortnightly interval.

Singh et al. (1990) who reported that NPK ratio of 120-60-60 Kg/ha increased the susceptibility of rice crop to rice stem borers.

Hasken and Poehling (1995) reported that synthetic fertilizers reduce plant resistance to insect pests tend to enhance insect pest populations and can increase the need for insecticide applications. For instance synthetic nitrogen fertilization increased aphid infestations on winter wheat.

Setamou et al. (1995) stated that the densities of stem borers and percentage of damaged plants were higher in fertilized plants than unfertilized plants in both elite and landrace cultivars. Soil fertility has been shown to affect not only plants but also the population dynamics of stem borers Nitrogen for example has been found to increase both survival and fecundity of stem borer, *Sesamia calamistis*.

Allan and Daine (1996) reported that earliest references to sulfur use for pest control either by burning the element or by adding the sulfur mixed with herbs ,oil or vinegar to the insect pest. Sulfur was used as fumigant for killing insects and larvae on plant fruit trees.

Quintero et al. (1998) reported K fertilization is associated with increasing crop growth because of the positive effect of this nutrient in osmotic adjustment, stomata regulation, photosynthesis, and protein synthesis.

Ravankar et al. (1998) reported that continuous application of 100 per cent NPK along with FYM 10 t/ha had a beneficial effect of available nitrogen and phosphorus content.

Yadav and Kumar (1998) revealed that the continuous application of NPK fertilizers alone at 100 % recommended level and their combination with FYM increased the available P content of soil over the initial status.

Singh and Kumar (1998) found significant increase in grain and biological yield of sorghum due to application of 100 % NPK through fertilizer followed by 50 % nitrogen through FYM.

Magdoff and Van (2000) stated that most pest management methods used by farmers can be considered soil fertility management strategies and vice versa. There are positive interactions between soils and

pests that once identified can provide guidelines for optimizing total agro ecosystem function. Increasingly, new research is showing that the ability of a crop plant to resist or tolerate insect pests and diseases is tied to optimal physical, chemical and mainly biological properties of soils. Soils with high organic matter and active soil biology generally exhibit good soil fertility as well as complex food webs and beneficial organisms that prevent infection. On the other hand, farming practices that cause nutrition imbalances can lower pest resistance.

Ponder et al. (2000) The nitrogen level in the diet of herbivores insects is the most important factor affecting their performance. The population of *Rhopalosiphum padi* is reported to be decreased on nitrogen deficient plants (Dixon, 1987; Ponder et al., 2000).

Sweeny et al. (2000) reported that application of potassium increases the yield of wheat crop and is also reported to have negative effect on aphid population.

Allsopp et al. (2001) reported that distribution and abundance of the stem borers may be influenced by microclimatic factors such as temperature and precipitation and biotic factors such as natural enemies and alternative host plants. In addition, soil nutrients have been found to play an important role in determining the distribution of pests.

Cruz et al. (2001) noted that nitrogen level of plant was absolutely associated with water contents and other minerals describing that an increase in nitrogen leads to softer tissues, which can direct more stem borer attack and more larval weights. It has been found that the rates of injury, densities, weight and sizes of larval body of *C. suppressalis* amplified significantly with the increase in nitrogen.

Godase and Patel (2001) reported that reduction in aphid population due to the application of organic manure in brinjal crop

Sureka and Rao (2001) indicated that application of FYM at 7.5t/ha was more effective in bringing down aphid population on okra. Similar observations were made by Yardim and Edwards (2003) when they

evaluated the effects of organic and synthetic fertilizer sources on pest and predatory insects associated with tomatoes.

Wang (2001) conducted a field trial with wheat and stated that N significantly stimulated honey production in two aphid species (*Sitobion avenae* and *Rhopalosiphum padi*) and balanced application of the three major nutrients is important for mediating the aphid population density. Several studies have established that balanced application of fertilizers is an integral component of crop management for realizing good crop yields and increased net returns in spite of higher fertilizer costs.

Prakash et al. (2002) explored the utility of organic manures for managing the pests of rice. Literature showed that very little work has been done on the effect of organic and inorganic sources of nutrients on insect pests of okra. In this context it was planned to study the effect of some organic manures in various combinations with inorganic fertilizers on the incidence of rice pests.

Alice et al. (2003) recorded the low BPH population in plots treated by organic amendments. The main cause is recognized by low of nitrogen content in rice plant.

Altieri and Nicolls (2003) recorded that leaf N content and leaf P content were lesser in the treatments of manure compost and organic fertilizer than control check that made rice yield relatively lower than control check (NPK fertilizer) excepted the treatment of organic fertilizer at the dose of 2.5 tons/ha. But there was no significantly different among treatments and control. Otherwise, leaf K content in the treatment of manure compost and organic fertilizer was higher than control check that was another reason to explain tolerance of rice plant to insect pests and diseases.

Ge et al. (2003) stated that fertilizers are a major input for increased agricultural productivity. The form of these inputs can influence pest population depending on the kind of fertilizer used, the crop grown and insect species present. Increasing level of nitrogen (N) fertilizer application

promotes the occurrence of herbivorous insects and crop damage from these insects by reducing plant resistance.

Fanta (2003) significant variations were recorded on harvest index and dead heart count of shoot fly due to the applied different levels of N and P. Furthermore, the interaction effects of NP treatment combinations were not significant for all parameters considered in the study except lodging percentage of *teff* at the prescribed area. Increasing the rate of N application significantly increased the grain and biomass yield of the early maturing. The maximum yield was recorded at 60kg N/ha. However, such rate has not shown statistically significant variation with 45 kg/ha.

Miguel and Clara (2003) observed that crops grown with organic matter generally exhibit less insect herbivores, reductions that may be attributed to a lower nitrogen content in organically farmed crops.

John (2004) stated that fertilizers in general are one of the major inputs for increased agricultural productivity. The form of these inputs can influence pest populations in various agro ecosystems, depending on the kind of fertilizers used, the crops grown, and the insect pests present. However, excessive nutrient application can also lead to pest problems by increasing the reproduction, longevity and overall fitness of certain pests.

Chau and Heong (2005) also revealed that the population of insect pests as stem borer, leaf folder on the chemical fertilizer treatment exhibited the severe outbreak more than in the treatments of organic fertilizer application.

Jiang and Schulthess (2005) conducted a laboratory and field trials to evaluate the effect of plant species (maize, sorghum), plant age (young, middle, old) and four different nitrogen fertilization levels (N_0 – N_3) on the bionomics of the invasive crambid *Chilo partellus* and they found that the level of nitrogen fertilization had no effect on food conversion efficiency of *C. partellus*. It was concluded that on depleted soils only, an increase in nitrogen via mulching, rotation with a leguminous crop or fertilization would increase survival of *C. partellus* on both maize and sorghum.

Prudic et al. (2005) revealed that balanced NPK application exhibited minimum aphid population as compared to sole application of N. Plant nutritional quality and plant defenses that directly act on herbivores are altered by N fertilization and the herbivorous insects can distinguish such alterations in plants.

Ramesh et al. (2005) concluded that organic crops have been shown to be more tolerant as well as resistant to insect attacks and organic rice is reported to have thicker cell wall and lower levels of free amino acid than conventional rice.

Ramzan et al. (2007) revealed that the lowest per cent incidence of stem borers was in the treatment where nitrogen was not applied at all that was at par with leaf colour chart (92 Kg / ha in three splits). The results further show that the pest incidence increases with the dose increase of nitrogen fertilizer application. The highest incidence (1.8%) of stem borers was recorded in 120 Kg/ha nitrogen application treatments.

Chen and Ruberson (2008) stated that fertilizers are a major input for increased agricultural productivity. The form of these inputs can influence pest population depending on the kind of fertilizer used, the crop grown and insect species present. Increasing level of nitrogen (N) fertilizer application promotes the occurrence of herbivorous insects and crop damage from these insects by reducing plant resistance. Plant nutritional status and defence systems that directly act on herbivores are altered by N fertilization

Ouda and Atif (2008) stated that Leaf chlorophyll content was significantly higher when inorganic fertilizer adding with organic manure compared with using organic manure alone. Application the highest dosages of organic manure (80 ton ha⁻¹) with highest dose of inorganic fertilizer (60 kg ha⁻¹) induced the highest leaf chlorophyll content, while the lowest chlorophyll content obtained by control treatment.

Shivayya et al. (2009) stated that, the incidence of shoot fly, stem borer and cob worm on maize at different levels of fertilizer revealed

that the highest incidence of shoot fly was noticed in doses $N_0P_0K_0$ (49.29%) and lowest in doses N:175 P:112.5 K:56.22 (21.28%) kg/ha. On the other hand NPK dose at the rate of 175:112.5:56.22 combinations reflects highest incidence of stem borer (10.14%) and cob worms (15.83%) and least was noticed in $N_0P_0K_0$ for both the insects (7.61 and 6.45% for stem borer and cut worms, respectively).

Cheema et al. (2010) stated that Nitrogen is a component of protoplasm, proteins, nucleic acids, chlorophyll and plays a vital role in vegetative and reproductive phases of crop growth. Higher nitrogen levels are reported to increase plant height, stem thickness, leaf area, leaf area index, dry matter accumulation; net assimilates ratio and yield per hectares.

Dong et al. (2011) revealed that positive relationship between K fertilization and grain abundance and suggested that K fertilization was extremely important for maintaining high yield. K fertilizer application is a most important practice to suppress pest population.

Addo and Thanguane (2012) studied that percentage of damaged plants were lower in unfertilized plants than fertilized plants. The percentage of damaged plants varied from 10 to 40% in fertilized elite plants and from 6.7 to 23.3 % in the unfertilized elite plants. In landrace, the percentage of damaged plants varied from 6.7 and 28.3 % in fertilized plants and from 8.3 to 18.3 % in unfertilized plants.

Aqueel and Leather (2012) revealed that availability of nitrogen affects the interaction between the prey and its predators. The predator (*Harmonia axyridis*) consumed more aphids from plants treated with low amount of nitrogen because the aphids on high nitrogen treated plants gained more body weight and were recorded non preferred by the predator.

Tetarwal et al. (2012) stated the general perception that unbalanced and excessive dose of nitrogenous fertilizers encourages heavy infestation of aphid on wheat crop and positive correlation between nitrogen doses and aphid population is found in some research trials. The

maximum incidence of aphid was observed on maximum dose of nitrogen while minimum was recorded in untreated check.

Arshad et al. (2013) conducted an experiment to check the efficacy of different nitrogen doses on the bionomics of maize stem borer *Chilo partellus* (Lepidoptera: Pyralidae) under laboratory and field conditions applied on three maize hybrids i.e., KK-8711, KWS-55 and KS-85. The results revealed that the body weight (mg) and frass weight (mg) of larvae positively correlated with nitrogen levels. There was a significant difference in weight gained by larval instars at various nitrogen applications with highest weight (0.085mg/l) at 150KgN/ha and minimum (0.078mg/l) at (0KgN/ha).

Karikari et al. (2013) studied the effect of fertilizer rates on the incidence of insect pests of *Sorghum bicolor* (L) Moench in the northern region of Ghana and he found that there were significant differences in the effects of the three fertilizer rates. These were higher rate (250 kg NPK +250 kg SA/ha), recommended rate (250 kg NPK +125 kg SA/ha) and no fertilizer as control. on the incidence of the different insects identified. However, considering a particular insect species the fertilizer rates did not show marked differences in their effects.

Liaqat et al. (2013) reported that balanced NPK fertilizer decreased the aphid population density significantly. On the contrary, plants fertilized with higher rates of nitrogen either alone or in combinations with other fertilizers depicted higher infestation of aphid in both seasons of study. Gradual increase in temperature was conducive for enhancing predator population. Increase in aphid population in unbalanced nutrition treatments tended to decline wheat grain yield.

Tanzubil (2014) studied the effect of variety and nitrogen fertilization on insect pest incidence in Sorghum in the Sudan Savanna of Ghana and he found that midge and stem borer damage were negligible. The importance of N fertilizers to increased Sorghum production was also demonstrated with a caution to limit application rate to below 50 kg to minimize adverse effects of insect pests and maintain or improve grain quality.

Aziz et al. (2015) conducted an experiment to evaluate the effect of different application of levels of nitrogen, phosphorous and potash (NPK) on the population of aphids and their natural enemies on wheat crop and found that population of *Rhopalosiphum padi* was minimum in N:P:K= 75:60:60 (kg/ha) while it was the maximum 90:60:75 treated plots.

CHAPTER III

MATERIAL AND METHODS

The present investigation entitled "Effect of manure and chemical fertilizer doses on the incidence of major pests of sorghum" was carried out at field of National Highway Block, CRS, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during *kharif* 2015-16 with a view to evaluate the effect of manure and chemical fertilizer doses on the incidence of major pests of sorghum and to determine different biochemical associated with sorghum affecting incidence of major pests. The material used and methods adopted during the course of investigations are described below.

3.1 Material

Material like different manure and chemical fertilizer, agricultural implements, bullock pair, marker, rope, measuring tape, Chlorophyll meter, labels, pens, brown paper bags etc. were used while conducting field experiment. For laboratory work material like small vials, test tubes, measuring cylinder, conical flask, volumetric flask, beaker, glass rod, filter paper, funnel and instruments like stereoscopic microscope, camera, weighing balance, grinder, hot air oven, water bath, digestion unit, centrifuge machine, spectrophotometer, colorimeter and flame photometer were used.

3.2 Methods

The details of field experiment are given below, while the plan of layout is illustrated in Fig. 1.



Plate 1 General View of Plot

3.2.1 Experimental details:

- Year of experiment : 2015 (*Kharif*)
- crop : Sorghum .
- Variety : CSH - 9
- Design of experiment : Randomized Block Design (RBD)
- No. of Treatments : 11 (Eleven)
- No. of Replications : 3 (Three)
- Spacing : Row to row : 45 cm
: Plant to plant : 15 cm
- Plot size :Gross: : 10 X 10 m²
Net: : 9.10 X 9.10 m²
- Sowing Date :21st July 2015
- Harvesting Date :20th Nov 2015

Experimental Treatments :

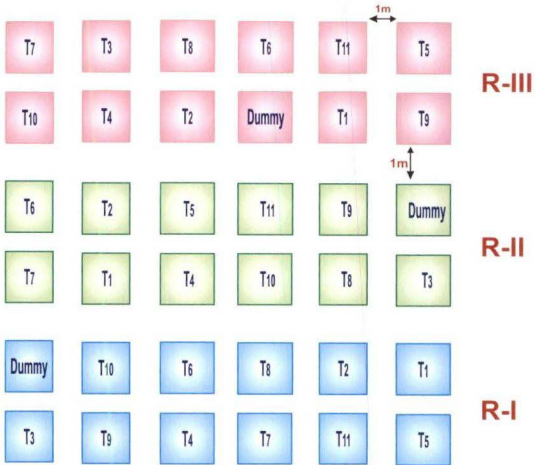
No. of Treatment	Treatments
T ₁	50 % NPK.
T ₂	100 % NPK.
T ₃	150 % NPK .
T ₄	100 % NPK S free.
T ₅	100 % NP.
T ₆	100 % N.
T ₇	100 % NPK + FYM@5t/ha.
T ₈	100 % NPK + 37.5 kg sulphur / ha.
T ₉	FYM @ 10 t /ha – Before sowing.
T ₁₀	75 % NPK + 25 % through FYM.
T ₁₁	Control.

Source:-

N:-Urea; P:-SSP; K:-MOP

Recommended dose of fertilizers

Sorghum: 100:50:40 kg N, P₂O₅ & K₂O per hectare



Design : Randomized Block Design (RBD)
Treatment : 11
Replication : 3

Fig. 1. Plan of layout

3.3 Cultural operations

3.3.1 Preparatory tillage

During summer, soil was ploughed with tractor drawn plough and two harrowing were given. Field was cleaned by collecting previous crop stubbles.

3.3.2 Layout of experiment

Field experiment was laid out in Randomized Block Design with eleven treatments replicated thrice. The gross plot size was 10m x 10m. and spacing was 45 cm x 15 cm. Distance between two replications was 1.0 m and between two treatment plots was 1.0 m.

3.3.3 Sowing

Marking of lines was done by wooden marker at spacing of 45 cm, sowing was done on 21st July 2015 by dibbling 3 to 4 seeds per hill at the depth of about 3.4 cm at a distance of 15 cm and then covered with soil carefully.

3.3.4 Application of fertilizers

The manure and chemical fertilizers were applied as per given treatment, respectively. The half dose of Nitrogen and full dose of Phosphorus and Potassium was applied at the time of sowing. Remaining half dose of Nitrogen was applied one month after sowing.

3.3.5 Hoeing and weeding

Hoeing and weeding operations were carried out from time to time to remove weeds and to improve soil aeration and to conserve soil moisture. In all three hoeing and three weeding were undertaken during the crop season.

3.4 Method of recording observations

The following observations on different treatment were carried out.

3.4.1 Numbers of plant

Total number of plant counted as per four line of 10m length in each plots at 12th day after emergence (Plate 1).

3.4.2 Numbers of eggs per plant

The total numbers of eggs per plant (Plate 2) were counted on 5 randomly selected plants in each plot at 7th and 14th days after emergence.

3.4.3 Shoot fly dead hearts

The dead hearts caused by shoot fly (Plate 2) were recorded at 14th, 21st and 28th days after emergence in each of the plot. Number of plant selected as per four line of 10m length in each plots. Per cent dead hearts were computed by the following formula:

$$\text{Dead heart (\%)} = \frac{\text{No. of plants with dead hearts in a plot}}{\text{Total no. of plants in the plot}} \times 100$$

3.4.4 Stem borer leaf injury.

The leaf injury caused by stem bore (Plate 3) were recorded at 35th days after emergence in each of the plot in the stem borer leaf injury rating in the scale of 1 to 9 in two rows 35th day after emergence (1 = <10, 2 = 11 – 20, 3 = 21 - 30, 4 = 31 – 40, 5 = 41 – 50, 6 = 51 – 60, 7 = 61 – 70, 8 = 71 – 80, 9 = > 80 % leaf area damaged by the larvae .

3.4.5 Aphids per cm²

The observation of aphids (Plate 4) the number of aphids per cm² on three leaves in five randomly selected plant.

3.4.6 Number of predator per plant

The observations of predator per plant were recorded on randomly selected 5 plants (Plate 5).

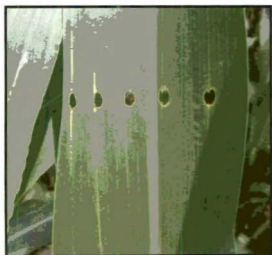


Shoot fly egg



Shoot fly dead hearts

Plate 2 Shoot fly eggs and Shoot fly dead hearts.



Stem borer leaf injury

Plate 3 Stem borer leaf injury



Aphid population

Plate 4 Population of aphids



Lady bird beetle



Spider

Plate 5 Population of Lady Bird Beetle and Spider.

3.5 Collection of experimental data on morphological parameters

3.5.1 Chlorophyll Content:

The chlorophyll content index of five randomly selected leaves in each plot was recorded at 28th days after germination by using SPAD-502 chlorophyll meter (Plate 6).

3.6 Nutrient studies.

The various biochemical parameters like Total Nitrogen, Phosphorus and Potassium content were estimated on 28 DAE (Plate 6).

a) Collection of samples

The leaf samples were collected from the plots. The collected leaves were oven dried; each sample was analyzed for per cent Nitrogen, per cent phosphorus and per cent potassium.

b) Preparation of sample for analysis

The dried leaves were powdered separately in grinding mill at Department of Agricultural Chemistry and Soil Science, so as to pass through 60 mesh size. The powdered material used for the biochemical estimation.

3.6.1 Total Nitrogen:

The total nitrogen concentration in sorghum leaves was determined by modified the Kjeldahl digestion colorimetric method as described by Cataldo et al. (1974)

Chemical Required per Sample for Digestion:

1. Conc. Sulphuric acid -10 ml
2. Catalyst Mixture ($\text{CuSO}_4 + \text{k}_2\text{SO}_4$)
3. Sample Weight -0.5 gm

Chemical required per Sample for distillation:

1. 40%NaOH – 30 ml
2. 4% Boric Acid – 20 ml
3. Indicator – Methyl red solution (2 or 3 drops)

Chemical required for titration:

1. Preheat the digestion System to 300⁰C.
2. Take 0.5 g of the given sample in the digestion tube.
3. Now add 3gms (approx) of catalyst mixture and finally add 10ml of Conc. Sulphuric acid to the sample and place the tubes in the digestion block along with manifold.
4. Switch on the scrubber system immediately.
5. Ensure any frothing of sample is there; if frothing is not there then increase the Temp to 420⁰C.
6. Leave the tubes in the block for 1 hour ensure the colour of the sample is turned into bluish green if not replace the tubes in the block for some time.
7. Once the bluish green colour appears the tubes and place then in the cooling stand.

Procedure for Distillation:

1. Ensure the 40% alkali tube and 4% boric acid tubes are filled properly in their respective tank with no air gaps.
2. Ensure water flow is there for condensation
3. Ensure the overhead tank is filled with Distilled water above the mark.
4. Load the digested sample and the empty conical flask in the system properly.
5. Switch on the Distillation system and wait for Ready Signal.
6. Set the appropriate values in the program for different parameter.

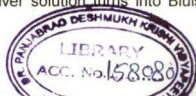
As follows

Boric acid: 20 ml

Alkali: 30 ml

Process time: 9 min

7. Then press the RUN button for the execution of the program.
8. Finally the pink color in the receiver solution turns into Bluish green colour.



Procedure for Titration:

Titration the distilled solution against 0.1 N H₂SO₄ once the color change from bluish green to permanent pale pink the burette reading (T.V).

Calculation:

$$\text{Nitrogen (\%)} = \frac{14 \times (\text{T.V}) \times 0.1 \text{ N} \times 100}{\text{Sample Weight} \times 1000} \times 100.$$

3.6.2 Phosphorous:

Phosphorous was analyzed in di-acid extract with Vanado molybdate using Spectrophotometer (Jackson, 1973).

Reagents

1. Ammonium molybdate, ammonium vandate in HNO₃

Dissolve 25 g ammonium molybdate in 400 ml of distilled water. Similarly, dissolve separately 1.25 g of ammonium metavanadate in 300 ml of boiling water. Add the metavanadate solution to the molybdate solution and cool to room temperature. Add 250 ml of conc. HNO₃ and dilute to 1 liter.

2. Standard phosphorus solution (50 mg P/liter or 50 ppm)

Dissolve 0.2195 g of analytical grade KH₂PO₄ (Potassium dihydrogen phosphate) and dilute to one liter. This solution contains 50 mg P/ml.

Procedure

- Digestion: Oven dried sorghum leaf samples of 0.2 g digest by 5 ml of H₂SO₄ and 5 ml of H₂O₂. Then, the final volume makes to 100 ml.
- Preparation of Standard Curve:-Transfer 0, 1, 2, 3, 4 and 5 ml of standard solution (50 ppm) to 50ml volumetric flask to get 0, 1, 2, 3, 4 and 5 ppm, respectively. Add 10 ml of vandomolybdate reagent to each flask. Make up the volume with distilled water and shake thoroughly. Read the absorbance of solution after 30 min at 470 nm with colorimeter using

blue filter. Draw a curve by plotting absorbance on Y axis and P concentration on X axis.

- Determination of Phosphorus:** - Pipette 10 ml of plant di-acid extract into a 50 ml volumetric flask, add 10 ml vanadomolybdate solution, 20 ml distilled water and mix well and make the volume up to 50ml. The colour develops rapidly but usually read after 30 min. A blank must be prepared, note the reading of the samples on 470 nm. The further calculations was done as per the following formula.

$$P (\%) = \text{Sample Conc. (ppm)} \times \frac{\text{Acid extract}}{\text{Wt. of sample}} \times \frac{\text{Final volume}}{\text{Aliquot taken (ml)}} \times 10000$$

3.6.3 Potassium

Potassium was analyzed in di- acid extract using Flame Photometer (Piper, 1966).

Procedure:

Total Potassium in plant was determined from the digested plant material by di- acid, tri- acid extract. From the extract potassium was determined with the help of Flame Photometer.

$$K (\%) = \text{Reading} \times \frac{5}{100} \times \frac{100}{\text{Sample wt. (g)}} \times \frac{100}{1000000}$$

3.7 Statistical Analysis

As per Gomez and Gomez (1984) the data obtained from the field and laboratory experiment were converted to appropriate transformations and were subjected to statistical analysis to test the level of significance. Moreover, the data thus collected on biochemical parameters associated with sorghum manure and chemical fertilizer treatment were correlated with major pests infestation.



Plate 6 Chlorophyll content index and Estimation of NPK content in sorghum leaves

CHAPTER IV

RESULTS AND DISCUSSION

To study the effect of different doses of manure and chemical fertilizers on the incidence of major pest of sorghum were carried out at national highway block CRS, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during *Kharif* season of 2015-16. Observations on number of shoot fly eggs and deadhearts were recorded at 7 & 14 and 14, 21 & 28 days after emergence, respectively. Observations on stem borer leaf injuries were recorded at 35 days after emergence. Observations on aphids were recorded per cm². Chlorophyll content index was recorded on 28 days after emergence. The data thus obtained were subjected to statistical analysis. The experimental findings are discussed here with under different headings and subheadings in the light of available literatures.

4.1 Number of shoot fly eggs per sorghum plant at 7 and 14 days after emergence

The observations of shoot fly oviposition were recorded on 7 and 14 days after emergence by recording number of eggs per plant. Thus, the data obtained was statistically analyzed. The results obtained are described here.

4.1.1. At 7 days after emergence

The data presented in Table 1 and graphically illustrated in Fig 2 indicates that the lowest egg laying of shoot fly was recorded in T₁₁-Control (0.27 egg/plant), followed by T₁-50 % NPK (0.27 egg/plant), T₁₀-75 % NPK + 25 % through FYM (0.33), T₉- FYM @ 10 t /ha – before sowing (0.33), T₇-100 % NPK + FYM @ 5t/ha (0.33 egg/plant), T₈-100 % NPK + 37.5 kg sulphur / ha (0.40 egg/plant), T₂-100 % NPK (0.40), T₄-100 % NPK S free (0.40 egg/plant) and these eight treatments were found at par with each other. Whereas, T₆-100 % N recorded highest number of eggs/plant (0.60 egg/plant). However, it was at par with T₃-150 % NPK (0.53 egg/plant) and T₅-100 % NP (0.53 egg/plant)

Table 1: Number of shoot fly eggs per sorghum plant at 7 and 14 days after emergence

Sr. No	Treatment	Shoot fly eggs/plant (mean)	
		7 days after emergence	14 days after emergence
1	50 % RDF of NPK.	0.27 (0.51)	0.53 (0.73)
2	100 % RDF of NPK.	0.40 (0.63)	0.60 (0.77)
3	150 % RDF of NPK.	0.53 (0.73)	0.93 (0.96)
4	100 % RDF of NPK S free.	0.40 (0.63)	0.60 (0.77)
5	100 % RDF of NP.	0.53 (0.73)	0.80 (0.89)
6	100 % RDF of N.	0.60 (0.77)	0.93 (0.96)
7	100 % RDF of NPK + FYM@5t/ha.	0.33 (0.57)	0.60 (0.77)
8	100 % RDF of NPK + 37.5 kg sulphur / ha.	0.40 (0.62)	0.67 (0.81)
9	FYM @ 10 t /ha – Before sowing.	0.33 (0.57)	0.47 (0.68)
10	75 % RDF of NPK + 25 % through FYM	0.33 (0.57)	0.53 (0.73)
11	Control.	0.27 (0.51)	0.47 (0.68)
F test		Sig	Sig
SE(m) ±		0.05	0.04
CD at 5 %		0.16	0.12
CV%		15.07	9.14

Figures in parentheses are corresponding square root transformed values.

4.1.2. At 14 days after emergence.

The data presented in Table 1 and graphically illustrated in Fig 2 indicates that the lowest egg laying of shoot fly was recorded in T₁₁- Control (0.47 egg/plant) followed by T₉- FYM @ 10 t /ha – before sowing (0.47 egg/plant), T₁-50 % NPK (0.53 egg/plant), T₁₀-75 % NPK + 25 % through FYM (0.53 egg/plant), T₂- 100 % NPK (0.60 egg/plant), T₄- 100 %

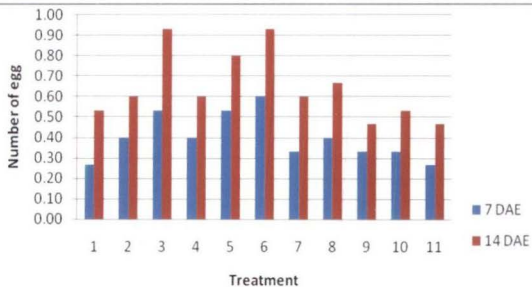


Fig.2 Number of shoot fly eggs per plant at 7 and 14 days after emergence.

NPK S free (0.60 egg/plant), T₇-100 % NPK + FYM @ 5t/ha (0.60 egg/plant) and these seven treatments were at par with each other. Whereas, T₆- 100 % N. recorded highest number of eggs/plant (0.93 egg/plant) however, it was at par with T₃-150 % NPK (0.93 egg/plant). Intermediate value of egg/plant was recorded in T₈-100 % NPK + 37.5 kg sulphur / ha (0.67 egg/plant), T₅-100 % NP (0.80 egg/plant) and were found at par with each other.

The literature on eggs laying by shoot fly *Atherigona soccata* on influenced by different doses of manure and fertilizers are lacking hence the present result, could not be discussed. However, it is general tendency of female fly to prefer lustrous and green leaves for egg laying due to nitrogenous fertilizer. In present investigation also egg laying of shoot fly was recorded maximum in treatment with higher nitrogenous fertilizer alone or in combination.

4.2 per cent dead hearts due to shoot fly

The observations on dead hearts due to shoot fly were recorded at 14, 21 and 28 days after emergence. The results obtained are described here under.

4.2.1 At 14 days after emergence

The data presented in Table 2 and graphically illustrated in Fig 3 revealed that the lowest per cent shoot fly dead hearts was recorded in T₁₁ –control (5.33 %) followed by T₁-50 % NPK (8.10%), T₉- FYM @ 10 t /ha – before sowing(8.17%).Whereas, highest number of dead hearts was recorded in T₆ -100%N(10.13%) however, it was at par with T₃-150 % NPK (9.13%), T₅-100 % NP (9.00%), T₂- 100 % NPK (8.77%), T₄- 100 % NPK S free (8.60%), T₇-100 % NPK + FYM @ 5t/ha (8.43%), T₁₀-75 % NPK + 25 % through FYM (8.33%), T₈-100 % NPK + 37.5 kg sulphur / ha (8.30%).

4.2.2 At 21 days after emergence.

The data presented in Table 2 and graphically illustrated in Fig 3 indicates that the lowest per cent shoot fly dead hearts was recorded in T₁₁ –control (9.17 %), followed by T₁-50 % NPK (11.17%), T₈- 100 %

NPK + 37.5 kg sulphur / ha (11.30%), T₉- FYM @ 10 t /ha – before sowing(11.80%), T₁₀- 75 % NPK + 25 % through FYM (11.90%), T₇-100 % NPK + FYM @ 5t/ha (12.13 %), T₄-100 % NPK S free (12.60%), T₂-100 % NPK (12.73 %), T₅-100 % NP (12.93 %), were found at par with each other. Whereas, the highest per cent shoot fly dead hearts was recorded in T₆- 100 % N (16.97 %) followed by T₃-150 % NPK (15.33%) and found at par with each other.

Table 2: Per cent sorghum shoot fly dead hearts at 14, 21 and 28 days after emergence and stem bore leaf injury at 35 days after emergence.

Sr.No	Treatment	Shoot fly Dead hearts (%)			Stem borer leaf injury rating (1-9 scale) 35 DAE
		14 DAE	21 DAE	28 DAE	
1	50 % RDF of NPK.	8.10 (2.85)	11.17 (3.33)	13.93 (3.73)	1.00 (1.00)
2	100 % RDF of NPK.	8.77 (2.95)	12.73 (3.57)	15.40 (3.92)	1.67 (1.28)
3	150 % RDF of NPK.	9.13 (3.01)	15.33 (3.74)	25.00 (4.33)	3.67 (1.91)
4	100 % RDF of NPK S free.	8.60 (2.93)	12.60 (3.54)	15.20 (3.90)	1.67 (1.28)
5	100 % RDF of NP.	9.00 (2.99)	12.93 (3.60)	15.60 (3.94)	2.33 (1.52)
6	100 % RDF of N.	10.13 (3.17)	16.97 (4.03)	31.67 (5.41)	4.00 (2.00)
7	100 % RDF of NPK + FYM@5t/ha.	8.43 (2.90)	12.13 (3.47)	15.17 (3.89)	1.67 (1.28)
8	100 % RDF of NPK + 37.5 kg sulphur / ha.	8.30 (2.88)	11.30 (3.36)	14.10 (3.75)	2.00 (1.41)
9	FYM @ 10 t /ha – Before sowing.	8.17 (2.85)	11.80 (3.42)	14.23 (3.77)	1.33 (1.14)
10	75 % RDF of NPK + 25 % through FYM	8.33 (2.88)	11.90 (3.45)	14.97 (3.86)	1.67 (1.28)
11	Control.	5.33 (2.15)	9.17 (3.03)	10.00 (3.16)	1.00 (1.00)
F test		Sig	sig	Sig	Sig
SE(m) ±		0.20	0.29	0.31	0.13
CD at 5 %		0.60	0.86	0.93	0.28
CV %		12.27	14.47	13.55	12.35

Figures in parentheses are corresponding square root transformed values

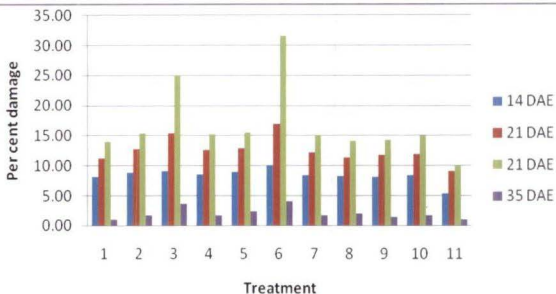


Fig.3 Per cent shoot fly dead hearts at 14, 21 and 28 days after emergence and stem borer leaf injury at 35 days after emergence.

4.2.3 At 28 days after emergence.

The data presented in Table 2 and graphically illustrated in Fig 3 indicates that the lowest per cent shoot fly dead hearts was recorded in T₁₁ –control (10.00%), followed by T₁-50 % NPK (13.93%), T₈- 100 % NPK + 37.5 kg sulphur / ha (14.10%), T₉- FYM @ 10 t /ha – before sowing (14.23%), T₁₀- 75 % NPK + 25 % through FYM (14.97%), T₇-100 % NPK + FYM @ 5t/ha (15.17 %), T₄-100 % NPK S free (15.20 %), T₂-100 % NPK (15.40 %), T₅-100 % NP (15.60%) and were found at par with each other. Whereas, the highest per cent shoot fly dead hearts was recorded in T₆- 100 % N (31.67 %) and was found at par with T₃-150 % NPK (25.00%).

The present findings are in close conformity with the finding of Shivayya et al. (2009) who recorded the incidence of shoot fly at different levels of fertilizer revealed that the highest incidence of shoot fly was noticed in NPK @ 175:112.5:56.22 (49.29%). Hasken and Poehling (1995) reported that synthetic fertilizers reduce plant resistance to insect pests tend to enhance insect pest populations and can increase the need for insecticide applications.

Chen and Ruberson (2008) also reported that increasing level of nitrogen (N) fertilizer application promotes the occurrence of herbivorous insects and crop damage from these insects by reducing plant resistance. Plant nutritional status and defence systems that directly act on herbivores are altered by N fertilization. Thus, the present investigation is in the tune to the previous findings.

4.2.4 Stem borer leaf injury at 35 days after emergence.

The data presented in Table 2 and graphically illustrated in Fig 3 indicates that the lowest stem borer leaf injury in the scale(1-9) was recorded in T₁₁ –control (1.00), which was at par with T₁-50 % NPK (1.00), T₉- FYM @ 10 t /ha – before sowing (1.33), T₂-100 % NPK (1.67), T₄-100 % NPK S free (1.67), T₇-100 % NPK + FYM @ 5t/ha (1.67), T₁₀- 75 % NPK + 25 % through FYM (1.67). Whereas, the highest stem borer leaf injury was recorded in T₆-100 % N (4.00) which was at par with T₃-150 % NPK (3.67). Intermediate value of leaf injury recorded in T₈- 100 % NPK +

37.5 kg sulphur / ha (2.00), T₅-100 % NP (2.33) and these two treatments were at par with each other.

The present findings on stem borer leaf injury was in conformity with earlier worker Addo and Thanguane (2012) who studied the percentage of damaged plants were lower in unfertilized plants than fertilized plants. The percentage of damaged plants varied from 10 to 40% in fertilized elite plants and from 6.7 to 23.3 % in the unfertilized elite plants. In landrace, the percentage of damaged plants varied from 6.7 and 28.3 % in fertilized plants and from 8.3 to 18.3 % in unfertilized plants whereas, Karikari et al. (2013) found that the higher incidence of stem borer on sorghum plants where fertilizer NPK 250 % used as compared to lower rate. Chau and Heong (2005) also revealed that the population of insect pests as stem borer, leaf folder on the chemical fertilizer treatment exhibited the severe outbreak more than in the treatments of organic fertilizer application.

Ramzan et al. (2007) recorded that the pest incidence with the dose increase of nitrogen fertilizer application. The highest incidence (1.8%) of stem borers was recorded in 120 Kg/ha nitrogen application treatments. Present findings are in accordance with Singh et al. (1990) who reported that NPK ratio of 120-60-60 Kg/ha increased the susceptibility of rice crop to rice stem borers. Saha and Saharia (1970) reported the incidence of stem borers from 8.36% in plots without nitrogen fertilizer to 20.12% in those treated with 100 Kg/ha. Thus, the results in terms of stem borer infestation are in accordance to the previous finding.

4.3 Number of sorghum plants per plot on 12 days after emergence.

The observations on number of plant per plot were taken from 4 lines of 10 M of each plot. The results obtained are described here.

The data presented in Table 3 and graphically illustrated in Fig. 4 indicates that the lowest plant population was recorded in T₁₁ – control (160), followed by T₆-100 % N (181.67), T₁-50 % NPK (207.33), T₉-FYM @ 10 t /ha – Before sowing. (210.0), T₂-100 % NPK (216.67), T₅-100 % NP (218.00) , T₁₀- 75 % NPK + 25 % through FYM (218.33), T₈ - 100 % NPK + 37.5 kg sulphur / ha. (220.0), T₃-150 % NPK (221.67), T₄-100 %

NPK + 37.5 kg sulphur / ha. (220.0), T₃-150 % NPK (221.67), T₄-100 % NPK S free (223.33), and these ten treatments were found at par with each other. The highest plant population was recorded in T₇-100 % NPK + FYM @ 5t/ha (243.33).

Table 3 Number of sorghum plants per plot on 12 days after emergence

Sr.No	Treatment	Total no. of plant/plot
1	50 % RDF of NPK.	207.33 (14.39)
2	100 % RDF of NPK.	216.67 (14.70)
3	150 % RDF of NPK.	221.67 (14.87)
4	100 % RDF of NPK S free.	223.33 (14.76)
5	100 % RDF of NP.	218.00 (14.76)
6	100 % RDF of N.	181.67 (13.04)
7	100 % RDF of NPK + FYM@5t/ha.	243.33 (15.55)
8	100 % RDF of NPK + 37.5 kg sulphur / ha.	220.00 (14.82)
9	FYM @ 10 t /ha – Before sowing.	210.00 (14.48)
10	75 % RDF of NPK + 25 % through FYM	218.33 (14.76)
11	Control.	160.00 (12.56)
F test		Sig
SE(m) ±		0.87
CD at 5 %		2.5
CV %		10.49

Figures in parentheses are corresponding square transformed values.

The present findings on total number of healthy plant observed was in conformity with earlier worker Ogunlela and Yusuf (1988) who reported that potassium application increased growth and yield in grain sorghum and also a valuable nutrient in decreasing the effects of

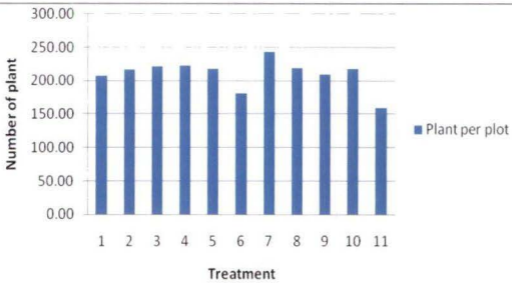


Fig.4 Number of sorghum plants per plot at 12 days after emergence.

reported K fertilization is associated with increasing crop growth because of the positive effect of this nutrient in osmotic adjustment, stomata regulation, photosynthesis, and protein synthesis. Plant population was maintained highest in recommended doses of fertilizer and manure and are in accordance with the stem fly infestation. Higher and lower doses of fertilizer and manure leads to succumb the seedling and poor growth, respectively.

4.4 Population of aphids, lady bird beetle and spider on sorghum leaves

4.4.1 Population of aphids

The observations were recorded on 28 days after emergence population of aphids per unit area / per cm². The results obtained are described here.

The data presented in Table 4 and graphically illustrated in Fig 5 revealed that the lowest population of aphids was recorded in T₁₁ - control (1.53), followed by T₉- FYM @ 10 t /ha – Before sowing (1.67), T₁- 50 % NPK.(2.07) and these three treatments were at par with each other. Whereas T₆- 100 % N recorded highest number of aphids population (4.13), however it was at par with T₃-150 % NPK. (3.67). Intermediate value of aphids population were recorded in T₄- 100 % NPK S free (2.40), T₅-100 % NP (2.40), T₈- 100 % NPK + 37.5 kg sulphur / ha. (2.40), T₂-100 % NPK (2.47), T₁₀- 75 % NPK + 25 % through FYM (2.47), T₇-100 % NPK + FYM @ 5t/ha (3.20) and these latter six treatments were found at par with each other.

The present findings are in corroboration with the finding of Aziz et al. (2015) who stated that population of aphids increases with application of nitrogen. Whereas, Weibull (1987) reported that application of nitrogen on barley increased the phloem cell sap, which proved more favorable for *Rhopalosiphum padi*. The population of *Rhopalosiphum padi* is reported to be decreased on nitrogen deficient plants. Emden (1966) found that increase in fecundity and development rates of green peach aphid, *Myzus persicae* were highly correlated to increased levels of soluble nitrogen in leaf tissue.

Prudic et al. (2005) revealed that balanced NPK application exhibited minimum aphid population as compared to sole application of N. Plant nutritional quality and plant defenses that directly act on herbivores are altered by N fertilization, and the herbivorous insects can distinguish such alterations in plants. Above results are also accordance with Tetarwal et al. (2012). Thus, the optimum nitrogenous fertilizer with P and K needs to be applied to keep the sucking pests population at low level.

4.4.2 Population of lady bird beetle (*Cheilomenes sexmaculata*)

The data presented in Table 4 and graphically illustrated in Fig 5 indicated that the lowest population of lady bird beetle was recorded in T₁₁-control (0.40), followed by T₆- 100 % N (0.50). These two treatments were at par with each other. Followed by T₃-150 % NPK(0.80). And T₅-100 % NP (0.87). Whereas T₇-100 % NPK + FYM @ 5t/ha recorded highest number of lady bird beetle population (3.00). followed by T₈- 100 % NPK + 37.5 kg sulphur / ha (2.33), T₂-100 % NPK (1.67) , However intermediate value of LBB population were recorded in T₁-50 % NPK (1.67) , T₁₀- 75 % NPK + 25 % through FYM (1.67), T₄- 100 % NPK S free (2.00) , T₉- FYM @ 10 t /ha – Before sowing (2.00) and these latter four treatments were found at par with each other.

The present findings are in close proximity with the finding of Aziz et al. (2015) who stated that population of lady bird beetles was the minimum in 105:60:60 and the maximum in 75:60:60. Whereas, similar result was found by Aqueel and Leather (2012) they revealed that availability of nitrogen affects the interaction between the prey and its predators. The predator consumed more aphids from plants treated with low amount of nitrogen because the aphids on high nitrogen treated plants gained more body weight and were recorded non preferred by the predator. Thus, the LBB population was observed in more number in balanced fertilizer and manure doses which harbored the predaceous fauna significantly.

4.4.3 Population of spider

The data presented in Table 4 and graphically illustrated in Fig 5 indicates that the lowest population of spider was recorded in T₁₁ - control (0.47), followed by T₆-100 % N(0.57), T₃-150 % NPK (0.67), T₅-100 % NP (0.87) these four treatments were at par with each other. Whereas, highest population of spider was recorded in T₇-100 % NPK + FYM @ 5t/ha (2.67), followed by T₂-100 % NPK (2.00), T₄- 100 % NPK S free (2.00) these three treatments were found at par with each other, However, intermediate population of spider were recorded in T₁-50 % NPK (1.33), T₉- FYM @ 10 t /ha – Before sowing (1.67), T₁₀- 75 % NPK + 25 % through FYM (1.67),and T₈- 100 % NPK + 37.5 kg sulphur / ha (1.95) and these four treatments were found at par with each other.

Table 4 Population of aphids, lady bird beetle and spider on sorghum plant

Sr.No	Treatment	Aphids /cm ²	Predators /plant	
			LLB	Spider
1	50 % RDF of NPK.	2.07 (1.44)	1.67 (1.28)	1.33 (1.14)
2	100 % RDF of NPK.	2.47 (1.57)	2.33 (1.52)	2.00 (1.41)
3	150 % RDF of NPK.	3.67 (1.91)	0.80 (0.89)	0.67 (0.81)
4	100 % RDF of NPK S free.	2.40 (1.55)	2.00 (1.41)	2.00 (1.41)
5	100 % RDF of NP.	2.40 (1.55)	0.87 (0.93)	0.87 (0.93)
6	100 % RDF of N.	4.13 (2.03)	0.50 (0.71)	0.57 (0.75)
7	100 % RDF of NPK + FYM@5t/ha.	3.20 (1.79)	3.00 (1.73)	2.67 (1.63)
8	100 % RDF of NPK + 37.5 kg sulphur / ha.	2.40 (1.55)	2.33 (1.52)	1.95 (1.38)
9	FYM @ 10 t /ha – Before sowing.	1.67 (1.29)	2.00 (1.41)	1.67 (1.28)
10	75 % RDF of NPK + 25 % through FYM	2.47 (1.57)	1.67 (1.28)	1.67 (1.28)
11	Control.	1.53 (1.24)	0.40 (0.62)	0.47 (0.68)
F test		Sig	Sig	Sig
SE(m) ±		0.10	0.08	0.09
CD at 5 %		0.30	0.24	0.29
CV		11.13	11.86	14.78

Figures in parentheses are corresponding square root transformed values.

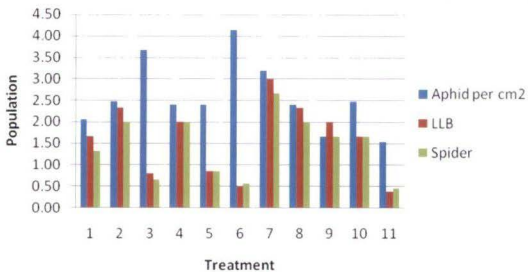


Fig.5 Population of aphids, lady bird beetle and spider on sorghum plant.

The present findings are in the tune to the findings of Aqueel and Leather (2012) who reported that availability of nitrogen affects the interaction between the prey and its predators. Population was decreases with increase in NPK fertilizer doses. Above results are also accordance with Aziz et al. (2015). Therefore, it is inferred that spider population also build up in the balance nutritional plants to mange the sucking pests naturally.

4.5 Biochemical profile of sorghum leaves in different treatments (Chlorophyll, N, P and K content as influenced by different treatments.)

4.5.1 Chlorophyll content index in sorghum leaves at 28 days after emergence

The data presented in Table 5 and graphically illustrated in Fig 6 indicates significant differences in chlorophyll content. The chlorophyll content index ranged between 23.13 to 31.18 in different treatments tested on 28 days after emergence.

The lowest chlorophyll content was recorded in treatment T₁₁ -control (23.13), followed by T₁-50 % NPK. (25.00) and T₉- FYM @ 10 t /ha – before sowing (26.70) these three treatments were at par with each other. Whereas T₆- 100 % N recorded highest chlorophyll content (31.18) which was at par with T₃-150 % NPK (30.95), T₂-100 % NPK (30.84), T₄- 100 % NPK S free (29.91), T₅-100 % NP (29.72), T₁₀- 75 % NPK + 25 % through FYM (29.20), T₇-100 % NPK + FYM @ 5t/ha (29.03), T₈- 100 % NPK + 37.5 kg sulphur / ha. (28.99), these seven treatments were at par with each other.

The present findings are corroborating with the findings of Ouda and Atif (2008) who found that Leaf chlorophyll content was significantly higher when added inorganic fertilizer. Application the highest dosages of organic manure (80 ton ha⁻¹) with highest dose of inorganic fertilizer (60 kg ha⁻¹) induced the highest leaf chlorophyll content, while the lowest chlorophyll content obtained by control treatment. Cheema et al. (2010).found Nitrogen is a component of protoplasm, proteins, nucleic

acids, chlorophyll and plays a vital role in vegetative and reproductive phases of crop growth. Higher nitrogen levels are reported to increase plant height, stem thickness, leaf area, leaf area index, dry matter accumulation and net assimilates ratio. Thus, higher the nitrogen fertilizer applied higher is the chlorophyll content.

4.5.2 Nitrogen content at 28 days after emergence

The data presented in Table 5 and graphically illustrated in Fig 7 indicates significant differences in nitrogen content. The nitrogen content ranged between 0.73 to 2.67% in different treatments tested at 28 days after emergence.

The lowest nitrogen content was recorded in T₁₁ -control (0.73%), which was at par with T₁-50 % NPK. (0.94%). The latter treatment containing more nitrogen was T₉- FYM @ 10 t /ha – before sowing (1.71%) which was at par with T₁₀- 75 % NPK + 25 % through FYM (1.73%) and T₅-100 % NP (1.78%), T₄- 100 % NPK S free (1.83%), T₈- 100 % NPK + 37.5 kg sulphur / ha(1.84%), T₂-100 % NPK (1.87%), T₆- 100 % N (1.93%), T₇-100 % NPK + FYM @ 5t/ha (2.25%). Whereas T₃-150 % NPK recorded highest nitrogen content (2.67%).

The present findings are in conformity with the finding of Muthuvel et al. (1977) who found that increases in available N content due to application of N through organic source. Amongst the fertilizers combination the NPK or NK treatment registered highest amount of available nitrogen. Similar result was also found by Ravankar et al. (1998)

4.5.3 Phosphorus content index at 28 days after emergence

The data presented in Table 5 and graphically illustrated in Fig 7 indicates significant differences in phosphorus content. The phosphorus content ranged between 0.21 to 0.64% in different treatments tested at 28 days after emergence.

The lowest phosphorus content was recorded in T₁₁ -control (0.21%), which was at par with T₆- 100 % N (0.28%) and T₁-50 % NPK

(0.38%). Whereas, T₇-100 % NPK + FYM @ 5t/ha recorded highest phosphorus content (0.64%). However, it was at par with T₃-150 % NPK (0.64%) and T₅-100 % NP (0.59%). Intermediate content of phosphorus was recorded in T₉- FYM @ 10 t /ha – Before sowing (0.40%), T₁₀-75 % NPK + 25 % through FYM (0.52%), T₂-100 % NPK (0.53%), T₄-100 % NPK S free (0.54%), T₈- 100 % NPK + 37.5 kg sulphur / ha (0.55%), which were at par with each other.

The present findings are in corroborative with the findings of Yadav and Kumar (1998) who revealed that the continuous application of NPK fertilizers alone at 100 % recommended level and their combination with FYM increased the available P content over the initial status. Similar result was obtained by Ravankar et al. (1998).

4.5.4 Potassium content at 28 days after emergence.

The data presented in Table 5 and graphically illustrated in Fig 7 indicates significant differences in percent potassium content. It was ranged between 0.95 to 3.07% in different treatments tested at 28 days after emergence.

The lowest potassium content was recorded in T₁₁-control (0.95%), followed by T₅-100 % NP (0.96%), T₆- 100 % N (0.97%) and these three treatments were found at par with each other. It was followed by T₉- FYM @ 10 t /ha – Before sowing (1.64%), T₁-50 % NPK (1.79%) and T₁₀- 75 % NPK + 25 % through FYM (2.06%) and these were at par with each other. Intermediate content of potassium was recorded in T₂-100 % NPK (2.12%), T₄-100 % NPK S free (2.16%), T₈- 100 % NPK + 37.5 kg sulphur / ha (2.20%), T₇ -100 % NPK + FYM @ 5t/ha (2.25%) and these four treatments were found at par with other. Whereas, T₃-150 % NPK recorded highest potassium content (3.07%).

Table 5 Chlorophyll content index and NPK content in sorghum leaves on 28 days after emergence

Sr.No	Treatment	Chlorophyll Index	N (%)	P (%)	K (%)
1	50 % RDF of NPK.	25.00	0.94 (0.88)	0.38 (0.61)	1.79 (1.34)
2	100 % RDF of NPK.	30.84	1.87 (1.37)	0.53 (0.73)	2.12 (1.46)
3	150 % RDF of NPK.	30.95	2.67 (1.63)	0.64 (0.74)	3.07 (1.75)
4	100 % RDF of NPK S free.	29.91	1.83 (1.35)	0.54 (0.73)	2.16 (1.47)
5	100 % RDF of NP.	29.72	1.78 (1.33)	0.59 (0.77)	0.96 (0.98)
6	100 % RDF of N.	31.18	1.93 (1.39)	0.28 (0.53)	0.97 (0.99)
7	100 % RDF of NPK + FYM@5t/ha.	29.03	2.25 (1.50)	0.64 (0.74)	2.25 (1.50)
8	100 % RDF of NPK + 37.5 kg sulphur / ha.	28.99	1.84 (1.36)	0.55 (0.74)	2.20 (1.48)
9	FYM @ 10 t /ha – Before sowing.	26.70	1.71 (1.31)	0.40 (0.63)	1.64 (1.28)
10	75 % RDF of NPK + 25 % through FYM	29.20	1.73 (1.31)	0.52 (0.72)	2.06 (1.44)
11	Control.	23.13	0.73 (0.85)	0.21 (0.46)	0.95 (0.97)
F test		Sig	Sig	sig	Sig
SE(m) ±		1.93	0.08	0.04	0.05
CD at 5 %		5.71	0.26	0.14	0.17
CV%		11.73	11.92	12.32	7.52

Figures in parentheses are square root transformed values.

The present findings are in accordance with the findings of Sharma et al. (1980) who reported favorable effect of NPK fertilization on available K content. Total potassium content was greatly increased due to application 100 % optimal NPK + FYM.

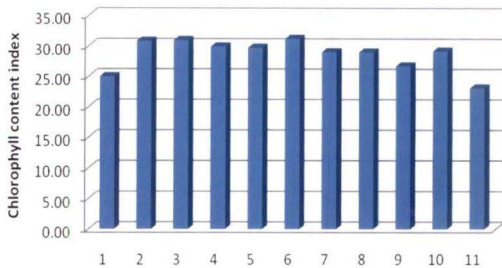


Fig. 6. Chlorophyll content index in sorghum leaves on 28 days after emergence

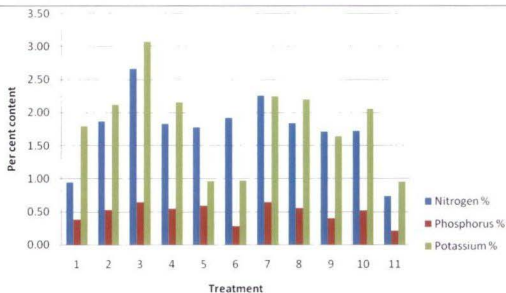


Fig.7 NPK content in sorghum leaves on 28 days after emergence.

4.6.1 Correlation between sorghum shoot fly dead hearts with chlorophyll, N, P and K contents.

The results depicted in Table 6 revealed that chlorophyll content recorded positive and significant association with per cent of shoot fly dead heart at 28 DAE ($r=0.638^*$). Further the nitrogen content recorded positive but some what weak correlation with per cent of shoot fly dead heart at 28 DAE ($r=0.559$). In respect with phosphorus content correlation recorded negative but weak association with per cent of shoot fly dead heart at 28 DAE ($r=-0.016$). Whereas, poor correlation was recorded in potassium content with percent of shoot fly dead heart at 28 DAE ($r=0.048$).

Table 6 Correlation between sorghum shoot fly dead hearts with chlorophyll, NPK Content

Shoot fly dead heart%	Chlorophyll Index	N (%)	P (%)	K (%)
13.93	25.00	0.94	0.38	1.79
15.40	30.84	1.87	0.53	2.12
25.00	30.95	2.67	0.64	3.07
15.20	29.91	1.83	0.54	2.16
15.60	29.72	1.78	0.59	0.96
31.67	31.18	1.93	0.28	0.97
15.17	29.03	2.25	0.64	2.25
14.10	28.99	1.84	0.55	2.20
14.23	26.70	1.71	0.40	1.64
14.97	29.20	1.73	0.52	2.06
10.00	23.13	0.73	0.21	0.95
r=	0.638*	0.559	-0.016	0.048

Table-at 5% ($r = 0.602$)

The present findings are in close conformity with the finding of Fanta (2003), who reported that the significant variations were recorded on harvest index and dead heart count of shoot fly due to the applied different levels of N and P furthermore, the interaction effects of NP treatment combinations were not significant for all parameters considered in the study. Thus in present investigation chlorophyll content and nitrogen

content showed positive correlation, it means favoured the shoot fly infestation. Whereas, phosphorus content had negative but weak correlation with shoot fly dead heart thus restrict the shoot fly infestation. Potash content showed poor correlation during the investigation hence could not be discussed. However, P and K provide hardiness to the plant and protect the plant from the infestation in general.

4.6.2 Correlation between sorghum stem borer leaf injury with chlorophyll, N, P and K contents.

The results depicted in Table 7 revealed that chlorophyll content recorded positive and significant association with per cent stem borer leaf injury at 28 DAE ($r=0.712^*$). Further the nitrogen also content recorded positive and significant association with per cent of stem borer leaf injury at 28 DAE ($r=0.667^*$). In respect with phosphorus content correlation recorded positive but poor correlation also with per cent of stem borer leaf injury at 28 DAE ($r=0.160$). However, correlation also recorded in potassium content with per cent of stem borer leaf injury at 28 DAE ($r=0.103$).

The present findings are in close conformity with the finding of Ghosh (1962) who observed relationship between nitrogen application and stem borer incidence due to the higher water content in stem and leaves of plants facilitated by uptake of higher nitrogen applied. easy to penetrate for the neonate larvae after hatching resulting into dead heart. Dong et al. (2011) revealed that positive relationship between K fertilization and grain abundance and suggested that K fertilization was extremely important for maintaining high yield. K fertilizer application is a most important practice to suppress pest population. also Beside N,P and K is also having important in growth of plant however ,manipulation in NPK doses are a great important to lower down the pest infestation.

Table 7 Correlation between sorghum stem borer leaf injury with chlorophyll, NPK Content

Shem borer leaf injury%	Chlorophyll Index	N (%)	P (%)	K (%)
1.00	25.00	0.94	0.38	1.79
1.67	30.84	1.87	0.53	2.12
3.67	30.95	2.67	0.64	3.07
1.67	29.91	1.83	0.54	2.16
2.33	29.72	1.78	0.59	0.96
4.00	31.18	1.93	0.28	0.97
1.67	29.03	2.25	0.64	2.25
2.00	28.99	1.84	0.55	2.20
1.33	26.70	1.71	0.40	1.64
1.67	29.20	1.73	0.52	2.06
1.00	23.13	0.73	0.21	0.95
r=	0.712*	0.667*	0.160	0.103

Table-at 5% ($r = 0.602$)

4.6.3 Correlation between sorghum aphids with chlorophyll, NPK Content

The results depicted in Table 8 revealed that chlorophyll content recorded positive and significant association with aphids population ($r=0.744^{**}$). Further the nitrogen content recorded positive and significant association with aphids population ($r=0.720^{*}$). In respect with phosphorus content correlation recorded positive but non significant association with aphids population ($r=0.281$). However correlation recorded positive but non significant association with aphids population ($r=0.258$).

The present findings are in close conformity with the finding of Surekha and Rao (2001) who showed that the application of FYM @ 7.5 t/ha was significantly more effective in bringing down the aphid population in. Reduction of aphids due to the application of organic manures have been reported in past.

Tetarwal et al. (2012) stated that unbalanced and excessive dose of nitrogenous fertilizers encourages heavy infestation of aphid and positive correlation between nitrogen doses and aphid population.

Table 8 Correlation between sorghum aphids with chlorophyll, NPK Content

Aphids/cm ²	Chlorophyll Index	N (%)	P (%)	K (%)
2.07	25.00	0.94	0.38	1.79
2.47	30.84	1.87	0.53	2.12
3.67	30.95	2.67	0.64	3.07
2.40	29.91	1.83	0.54	2.16
2.40	29.72	1.78	0.59	0.96
4.13	31.18	1.93	0.28	0.97
3.20	29.03	2.25	0.64	2.25
2.40	28.99	1.84	0.55	2.20
1.67	26.70	1.71	0.40	1.64
2.47	29.20	1.73	0.52	2.06
1.53	23.13	0.73	0.21	0.95
r=	0.744**	0.720*	0.281	0.258

Table-at 5% ($r = 0.602$)

Table-at 1% ($r = 0.735$)

4.7 Grain and fodder yield of sorghum in quintal per hectare:-

The data presented in Table 9 and graphically illustrated in Fig 8 indicates that the significantly higher grain yield was obtained from T₇-100 % NPK + FYM @ 5t/ha (29.17 qtl/ha) followed by T₈-100 % NPK + 37.5 kg sulphur / ha. (22.86 qtl/ha), Latter was on at par with T₁₀- 75 % NPK + 25 % through FYM (21.55 qtl/ha) and T₂-100 % NPK (21.34 qtl/ha). Intermediated yield level were recorded in T₄-100 % NPK S free (18.49 qtl/ha). followed by T₅-100 % NP (17.66 qtl/ha), T₃-150 % NPK (16.48 qtl/ha) and T₁-50 % NPK (15.45 qtl/ha). were found at par with each other. Significantly lower yield was obtain from T₁₁-control (3.44 qtl/ha) followed by T₆-100 % N (12.03 qtl/ha) and T₉- FYM @ 10 t /ha – before sowing (14.77 qtl/ha). Thus, the balance and optimum NPK with FYM yielded more in sorghum and equally provide tolerance to plant against to shoot fly and stem borer.

Table 9 Grain and Fodder yield of sorghum in quintal per hectare

Sr. No.	Treatment	Yield per ha (qtl/ha)	Fodder yield (qtl/ha)
1	50 % RDF of NPK.	15.45	28.73
2	100 % RDF of NPK.	21.34	39.20
3	150 % RDF of NPK.	16.48	43.88
4	100 % RDF of NPK S free.	18.49	36.33
5	100 % RDF of NP.	17.66	31.82
6	100 % RDF of N.	12.03	22.34
7	100 % RDF of NPK + FYM@5t/ha.	29.17	61.06
8	100 % RDF of NPK + 37.5 kg sulphur / ha.	22.86	45.11
9	FYM @ 10 t /ha – Before sowing.	14.77	29.77
10	75 % RDF of NPK + 25 % through FYM	21.55	40.02
11	Control.	3.44	6.36
SE(m) ±		1.13	2.24
CD at 5 %		3.34	6.62
CV %		11.17	11.12

The data presented in Table 9 and graphically illustrated in Fig 8 indicates that the significantly higher fodder yield was obtained from T₇-100 % NPK + FYM @ 5t/ha (61.06 qtl/ha) followed by T₈- 100 % NPK + 37.5 kg sulphur / ha. (45.11 qtl/ha), Latter was on at par with T₃-150 % NPK (43.88 qtl/ha), T₁₀- 75 % NPK + 25 % through FYM (40.02 qtl/ha) and T₂- 100 % NPK (39.20 qtl/ha). Intermediated yield level were recorded in T₉- FYM @ 10 t /ha – before sowing (29.77 qtl/ha), T₅-100 % NP (31.82 qtl/ha), T₄-100 % NPK S free (36.33 qtl/ha).were found at par with each other. Significantly lower yield was obtain from T₁₁ –control (6.36 qtl/ha) followed by T₆-100 % N (22.34 qtl/ha) and and T₁-50 % NPK (15.45 qtl/ha). Were found at par with each other. Thus, the balance and optimum NPK with FYM yielded more in sorghum and equally provide tolerance to plant against to shoot fly and stem borer.

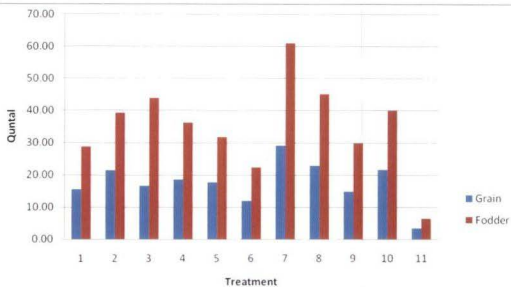


Fig.8 Grain and fodder yield of sorghum in quintal per hectare.

The present findings are in close conformity with the finding of Singh et al. (1998) found significant increase in grain and biological yield of sorghum due to application of 100 % NPK through fertilizer followed by 50 % nitrogen through FYM.

CHAPTER V

SUMMARY AND CONCLUSIONS

The present investigation, entitled " Effect of manure and Chemical fertilizer doses on the incidence of major pests of sorghum, was carried out at the field of national highway block, CRS, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during *Kharif* season of 2015-16.

In this programme all eleven treatments were replicated thrice under Randomized Block Design to out effect of manure and Chemical fertilizer doses on the incidence of major pests of sorghum. The data were calculated on the number of shoot fly eggs per plant at 7 and 14 DAE, shoot fly dead hearts percentage at 14, 21 and 28 DAE, stem borer dead heart percentage at 35 DAE. Similarly, data were collected on the population of aphids, Lady bird beetle and spider. Besides, this the data were also generated on chlorophyll content, Nitrogen, phosphorus & potassium content in sorghum plant associated with manure and Chemical fertilizer doses.

Correlation describes the interrelationship between shoot fly dead hearts, stem borer dead hearts and aphids population with content of chlorophyll, Nitrogen, phosphorus and potassium.

The results on each parameter and cumulative data consolidated are and summarized below.

5.1 Number of shoot fly eggs per plants.

The data on number of eggs per plant on 7 DAE indicated that highest no of eggs/plant was recorded in T₆-100 % N (0.60 egg/plant), however it was at par with T₃-150 % NPK (0.53 egg/plant) and T₅-100 % NP (0.53 egg/plant). Whereas lowest egg laying of shoot fly was recorded in T₁₁- Control (0.27 egg/plant), followed by T₁-50 % NPK. (0.27 egg/plant), T₁₀-75 % NPK + 25 % through FYM (0.33).

Similar result was found on 14 DAE where T₆- 100 % N. recorded highest no of eggs/plant (0.93 egg/plant). However, it was at par

with T₃-150 % NPK (0.93 egg/plant). Whereas, the lowest egg laying of shoot fly was recorded in treat. T₁₁- Control (0.47 egg/plant), followed by T₉- FYM @ 10 t /ha – Before sowing. (0.43 egg/plant), T₁-50 % NPK. (0.53 egg/plant).

5.2 per cent dead hearts due to shoot fly

The data on per cent dead hearts on 14 DAE indicated that highest per cent dead hearts were recorded in T₆ -100%N(10.13%), however it was at par with T₁₀-75 % NPK + 25 % through FYM (8.33). Whereas, lowest per cent shoot fly dead hearts was recorded in T₁₁ – control (5.33 %), followed by T₁-50 % NPK.(8.10 %).

Per cent dead hearts on 21 DAE indicated that highest per cent dead hearts were recorded in T₆- 100 % N (16.97 %) and was found at par with T₃-150 % NPK (15.33%). Whereas, the lowest per cent shoot fly dead hearts was recorded in T₁₁ –control (9.17 %), followed by T₁-50 % NPK (11.17%), T₈- 100 % NPK + 37.5 kg sulphur / ha (11.30%).

The data on per cent dead hearts on 28 DAE indicated that highest per cent dead hearts were recorded in T₆- 100 % N (31.67 %) and was found at par with T₃-150 % NPK (25.00%). Whereas, the lowest per cent shoot fly dead hearts was recorded in T₁₁ –control (10.00%), followed by T₁-50 % NPK (13.93%), T₈- 100 % NPK + 37.5 kg sulphur / ha (14.10%).

5.3 per cent stem borer leaf injury at 35 days after emergence.

The data on leaf injury in the scale of (1-9) on 35 DAE indicated that highest leaf injury were recorded in T₆-100 % N (4.00%) which was at par with T₃-150 % NPK (3.67%) while minimum leaf injury were recorded in. T₁₁ –control (1.00%), which was at par with T₁-50 % NPK (1.00%).

5.4 Total number of plant per plot

The data on plant population indicated that the highest plant population was recorded in T₇-100 % NPK + FYM @ 5t/ha (243.33) while the lowest plant population was recorded in T₁₁-control (160), followed by T₆-100 % N (181.67), T₉- FYM @ 10 t /ha – Before sowing. (210).

5.5 Population of aphids, lady bird beetle, spider

5.5.1 Population of aphids

The data on aphid population revealed that the T₆- 100 % N recorded highest number of aphids population (4.13). However, it was at par with T₃-150 % NPK. (3.67). However, the lowest population of aphids was recorded in T₁₁ -control (1.53), followed by T₉- FYM @ 10 t /ha – Before sowing (1.67) and these two treatments are at par with each other.

5.5.2 Population of lady bird beetle

The data on LBB population recorded that highest number of lady bird beetle reported on T₇-100 % NPK + FYM @ 5t/ha (3.00). While, lowest population were recorded in T₁₁-control (0.40), followed by T₆- 100 % N (0.50).

5.5.3 Population of spider

The data on spider population recorded that highest number of spider reported on T₇-100 % NPK + FYM @ 5t/ha (2.67), followed by T₂- 100 % NPK (2.00). While, lowest population were recorded in T₁₁ -control (0.47), followed by T₆-100 % N (0.57),

5.6 Biochemical profile of sorghum leaves in different treatments

5.6.1 Chlorophyll content index in sorghum leaves at 28 days after emergence

The chlorophyll content index ranged between 23.13 to 31.18 on 28 days after emergence. Among different treatments T₆- 100 % N recorded highest chlorophyll content (31.18) which was at par with T₂-100 % NPK (30.84) and T₃-150 % NPK (30.95) while lowest chlorophyll content

was recorded in treatment T₁₁ -control (23.13), followed by T₁-50 % NPK (25.00) and T₉- FYM @ 10 t /ha – Before sowing (26.70).

5.6.2 Nitrogen content in sorghum leaves at 28 days after emergence.

The nitrogen content ranged between 0.73 to 2.67% in different treatments tested at 28 days after emergence. Among different treatments T₃-150 % NPK recorded highest nitrogen content (2.67%). While, the lowest nitrogen content was recorded in T₁₁ -control (0.73%), which was at par with T₁-50 % NPK. (0.94%).

5.6.3 Phosphorus content in sorghum leaves at 28 days after emergence

The phosphorus content ranged between 0.21 to 0.64 % in different treatments tested at 28 days after emergence. Among different treatments T₇ -100 % NPK + FYM @ 5t/ha recorded highest phosphorus content (0.64%).however, it was at par with T₃-150 % NPK (0.64%) and T₅-100 % NP (0.59%). Whereas, The lowest phosphorus content was recorded in T₁₁ -control (0.21%), which was at par with T₆- 100 % N (0.28%) and T₁-50 % NPK. (0.38%).

5.6.4 Potassium content in sorghum leaves at 28 days after emergence

The potassium content ranged between 0.95 to 3.0%in different treatments tested at 28 days after emergence. Among different treatments T₃-150 % NPK recorded highest potassium content (3.07%). However, the lowest potassium content was recorded in T₁₁-control (0.95%), followed by T₅-100 % NP (0.96%), T₆- 100 % N (0.97%) and these three treatments were found at par with each other.

5.7.1 Correlation between shoot fly dead hearts and stem borer leaf injury with chlorophyll and NPK contents

The results revealed that chlorophyll content recorded positive and significant association with per cent of shoot fly dead heart at 28 DAE ($r=0.638^*$). Further the nitrogen content recorded positive but some

what weak correlation with per cent of shoot fly dead heart at 28 DAE ($r=0.559$). In respect with phosphorus content correlation recorded negative but weak association with per cent of shoot fly dead heart at 28 DAE ($r=-0.016$). Whereas poor correlation was recorded in potassium content with percent of shoot fly dead heart at 28 DAE ($r=0.048$).

The results revealed that chlorophyll content recorded positive and significant association with per cent stem borer leaf injury at 28 DAE ($r=0.712^*$). Further the nitrogen also content recorded positive and significant association with per cent of stem borer leaf injury at 28 DAE ($r=0.667^*$). In respect with phosphorus content correlation recorded positive but poor correlation also with per cent of stem borer leaf injury at 28 DAE ($r=0.160$). However, correlation also recorded in potassium content with per cent of stem borer leaf injury at 28 DAE ($r=0.103$).

5.7.2 Correlation between aphids with chlorophyll and NPK contents.

The results revealed that chlorophyll content recorded positive and significant association with aphids population ($r=0.744^{**}$). Further the nitrogen content recorded positive and significant association with aphids population ($r=0.704^*$). In respect with phosphorus content correlation recorded positive but non significant association with aphids population ($r=0.281$). However, correlation recorded positive but non significant association with aphids population ($r=0.258$).

5.8 Grain and fodder yield of sorghum

The highest grain yield was recorded in T₇-100 % NPK + FYM @ 5t/ha (29.17 q/ha).while lowest yield was recorded in T₁₁ –control (3.44 q/ha), followed by T₆-100 % N (12.03 q/ha), T₉- FYM @ 10 t /ha – before sowing. (14.77 q/ha).While, The highest fodder yield was recorded in T₇-100 % NPK + FYM @ 5t/ha (61.06 q/ha).Whereas, lowest yield was recorded in T₁₁ –control (6.36 q/ha), followed by T₆-100 % N (22.34 q/ha), T₁ 50% NPK (28.73 q/ha) in ascending order.

CONCLUSIONS

- Higher dose of nitrogenous fertilizer alone (100% RDF of N) favours the infestation of pests and population followed by 150% NPK in *kharif* sorghum.
- 100% RDF of NPK, 100% RDF of NPK + FYM 5 t/ha, 100% RDF of NPK + sulphur (37.5kg) and FYM 10 ton/ha. could keep the pest infestation and population at low level in *kharif* sorghum .
- 100% RDF of NPK+5 ton FYM could harbour the pest population at low level equally could also produce higher grain yield (29.17qt/ha) as well as fodder yield(61.06qt/ha)
- 100% RDF of N alone and 150% RDF of NPK increases the chlorophyll content in sorghum which favour the infestation of aphid , shoot fly and stem borer. Thus, it is needed to apply balanced and optimum doses of NPK to minimize the pest infestation level in sorghum.
- Predatory fauna viz.: lady bird beetle and spider were observed in more number in 100% RDF of NPK + 5t/ha FYM. It is inferred that predatory fauna also preferred the prey feeding on balanced NPK with organic manures. Thus balance fertilizer and manure favoured the predators.
- Chlorophyll index, per cent nitrogen showed significantly positive correlation with per cent shoot fly dead hearts, per cent stem borer dead hearts and Aphid population. Whereas, phosphorus content had negative but poor correlation with the infestation, while per cent potassium content showed poor correlation with the shoot fly and stem borer infestation .

Over all it is concluded that manipulation in inorganic fertilizers with organic manures needs to be emphasized in pest management of sorghum as one of the component of IPM.

CHAPTER VI

LITERATURE CITED

- Addo-Bediako, and Thaguane (2012) Stem borer distribution in different sorghum cultivars as influenced by soil fertility .Agricultural Science Research Journal Vol. 2(4) pp. 189 – 194.
- Ahmad AH, Qadir I, and Mahmood N (2007) Effect of integrated use of organic and inorganic fertilizers on fodder yield of sorghum (*Sorghum bicolor* L.) Pak. J. Agri. Sci., Vol. 44(3), 415
- Alice J, Sujeetha RP, and Venugopal MS (2003) Effect of organic farming on management of rice brown plant hopper. IRRN 28.2: 36-37
- Allan ES, and Diane MS (1996) A Compendium of Inorganic Substances Used in European Pest Control before 1850.
- Allsop PG, Sullivan GT, Hayson MBC, and Morgan TA (2001) Relationship of adaphic factors, location and harvest date to population levels of *Saccharicoccus sacchari* (Hemiptera: Pseudococcidae) on sugar cane. Environmental Entomology 22: 1278-1284
- Altieri MA, and Nicolls CI (2003) Soil fertility management and insect pests: harmonizing soil and plant health in agroecosystems. Soil & Tillage Research 72:203-211
- Anonymous. 2013. Crops. Sorghum at [http:// www.icrisat.org](http://www.icrisat.org).
- Anonymous. 2014. Area, Production and productivity of principal crops during 2010 11 in M.S. at <http://www.mahaagri.gov.in>
- Arshad MJ, Freed S, Akbar S, Akmal M, and Gul HT (2013) Nitrogen Fertilizer Application in Maize and Its Impact on the Development of *Chilo partellus* (Lepidoptera: Pyralidae). Pakistan J. Zool., vol. 45(1), pp. 141-147.
- Aqueel MA, and Leather SR (2012) Effect of nitrogen fertilizer on the growth and survival of *Rhopalosiphum padi* (L) and *Sitobion avenae* (F) (Homoptera: Aphididae) on different wheat cultivars. Crop Prot., 30: 216-221.
- Aruna C, Padmaja PG, Subbarayudu B, and Seetharama N (2011) Genetics of traits associated with shoot fly resistance in post-rainy season sorghum (*Sorghum bicolor* L.) Indian J. Genet. 71 (1): 9-16.
- Aziz MH, Bodlah I, Naeem M, and Shabbir G (2015) Effect of different doses of fertilizers on wheat aphids and their natural enemy in Pothwar, Punjab. Asian J. Agri Biol, 2015 3 (1):34-40.
- Balasubramanian G, Balasubramanian M, Sankaran K, and Manickam TS (1986) Effect of fertilization on the incidence of shoot fly and stem

borer on rainfed sorghum. Madras Agricultural Journal 1986 Vol. 73 No. 8 pp. 471-473.

- Cataldo DA, Schrader LE, and Youngs BL (1974) Analysis by digest and colorimetric assay of total nitrogen in plant tissue high in nitrate. *Crop Science*. 1974;14(6):854-856.
- Chau LM, and Heong KL (2005) Effects of organic fertilizers on insect pest and disease of rice. *Omonrice* 13: 26-33.
- Chen Y, and Ruberson JR (2008) Impact of variable nitrogen fertilization on arthropods in cotton in Georgia, USA. *Agric. Ecosyst. Environ.*, 126: 281-288.
- Cheema MA, Farhad W, Saleem MF, Khan HZ, Munir A, Wahid MA, Rasul F, and Hammad HM (2010) Nitrogen management strategies for sustainable maize production. *Crop Environ.* 1: 49-52
- Cruz LM, Souza EM, Weber OB, Baldani JI, Dobereiner J, and Pedrosa FO (2001) Ribosomal characterization of nitrogen-fixing bacteria isolated from banana (*Musa spp.*) and pineapple (*Ananas comosus* (L.) Merrill). *Appl. environ. Microbiol.* 67:2375-3279.
- Dauda S N, Ajayi FA, and Ndor E (2005) Growth and yield of water melon (*Citrullus lanatus*) as affected by poultry manure application. *J. Agric. Soc. Sci.*, 4, 2008 121-124.
- Dong H, Xiangqiang K, Li W, Wei T, and Dongmei Z (2011). Effects of plant density and nitrogen and potassium fertilization on cotton yield and uptake of major nutrients in two fields with varying fertility. *Field Crops Res.*, 119: 106-113.
- Emden HF (1966) Studies on the relations of insect and host plant. III. A comparison of the reproduction of *Brevicoryne brassicae* and *Myzus persicae* (Hemiptera: Aphididae) on brussels sprout plants supplied with different rates of nitrogen and potassium. *Entomological Experiments Applied* 9:444-460.
- Fanta MG (2003) Response of Teff [*Eragrostis tef* (zuuc)] to Applied Nitrogen and Phosphorus in vertisol of Raya Valley, South Tigray
- Ghosh RLM (1962) Rice in India, Indian Council of Agricultural Research, New Delhi, pp. 248-257.
- Ge F, Liu X, Li H, Men X, and Su J (2003) Effect of nitrogen fertilizer on pest population and cotton production. *Chin. J. Appl. Ecol.*, 14: 1735-1738.
- Godase SK, and Patel CB (2001) Studies on the influence of organic manures and fertilizers doses on the intensity of pests infesting brinjal. *Pl. Pro. Bull.*, 53: 10-12. sucking .Hsieh SC. 1995. Technology for sustainable agriculture in Taiwan.

- Gomez KA, and Gomez AA (1984) *Statistical Procedures for Agricultural Research*. John Wiley and Company, New York, pp.680.
- Hasken KH, and Poehling H M (1995) Effects of different intensities of fertilizers and pesticides on aphids and aphid predators in winter wheat. *Agric. Ecosyst. Environ.* 52:45-50.
- Jackson ML (1973) *Soil Chemical Analysis*. Published by Printice Hall, New Delhi 468.
- John GC (2004) "Effect of soil nutrients on the growth, survival and fecundity of insect pests of rice. Multitrophic interactions in Soil and Integrated Control". International Organization for Biological Control (IOBC) *wprs Bulletin* 27 (1): 115-122.
- Jiang N, and Schulthess F (2005) The effect of nitrogen fertilizer application to maize and sorghum on the bionomics of *Chilo partellus* (Lepidoptera: Crambidae) and *Bulletin of Entomological Research / Volume 95 / Issue 06 / December 2005*, pp 495-504.
- Jotwani MG (1982) Factor reducing sorghum yields –Insect pests. In: L. R. House, L. K. Mughogho and J. N. peacock (Eds), *Sorghum in eighties, Proceedings of the International symposium on sorghum, 2-7 November, 1981, 251-255*. International Institute for Semi Arid Tropics, patencheru, 502324, Andhra Pradesh.
- Karikari AS, Atokple IDK, Buah SS, Abdulai AL, Etwire PM, and Asungre P (2013) Effect of fertilizer rates on the incidence of insect pests of *Sorghum bicolor* (L) Moench in the northern region of Ghana. IV International Symposium „Agrosym 2013
- Kandalkar HG, and Narkhede SS (1989) Synthetic pyrethroids and plant extracts against sorghum shoot fly, some observations. *Pesticides* 23(4); 24.
- Karimullah A, Khan MS, and Raqib DRR (1986) Effectiveness of different methods of application of granular insecticides against maize stem borer in maize.
- Katole SR (1989) Studies on the integrated pest control of the internal feeder of sorghum. Ph.D. Thesis Submitted to Dr. PDKV, Akola.
- Kandalkar HG, Men UB, Atale SB, and Kadam PS (1989) Sorghum shoot fly population dynamics as influenced by ecological factors. *Indian J. Environ, and Ecoplan.* 5(2); 403 - 406.
- Liaqat A, Muhammad A, Mushtaq A, and Masood QW (2013) Inorganic Fertilization of Wheat in Relation to Aphid Infestation, Natural Enemies Population, Growth and Grain Yield. *International Journal of Agriculture and Biology*, 04:719–724.
- Magdoff F, and Van EH (2000). *Building Soils for Better Crops*. SARE, Washington, DC.

- Maluleke MH, Addo-Bediako A, and Ayisi KK (2005) Influence of maize/lablab intercropping on lepidopterous stem borer infestation in maize. *J. Econ. Entomol.*, 98: 384-388.
- Miguel AA, and Clara IN (2003) Soil fertility management and insect pests: harmonizing soil and plant health in agro ecosystems. *Soil and Tillage Research* Vol. 72 (2): 203-211.
- Mote UN (2003) Pest management in Sorghum. Paper presented at Marathwada Agricultural University.
- Muthuvel P, Kandaswamy P, and Krishnamoorthy KK (1977) Available of NPK under long term fertilization. *Madras Agric. J* 64;358-362.
- Ouda and Atif (2008) Effect of Fertilizers on Growth, Yield, Yield Components, Quality and Certain Nutrient Contents in Broccoli (*Brassica oleracea*). *International journal agriculture and biology*. of Print: 1560-8530; ISSN Online: 1814-9596 08-253/HUT/2008/10-6-627-632 <http://www.fspublishers.org>
- Ogunlela VB, and Yusuf Y (1988) Yield and growth response to potassium of grain sorghum as influenced by variety in a savanna soil of Nigeria. *Fertilizer Research* 16, 217-226.
- Pawar VM, Jadhav GD and Kadam BS (1984) Compatibility of Oncol 50 SP with different fungicides on sorghum (CS 3541) against shoot fly (*Atherigona soccata* Rondani). *Pestic.*, 18: 9-10.
- Ponder KL, Pritchard J, Harrington R, and Bale JS (2000) Difficulties in location and acceptance of phloem sap combined with reduced concentration of phloem amino acids explain lowered performance of the aphid *Rhopalosiphumpadi* on nitrogen deficient barley (*Hordeumvulgare*) seedlings. *EntomolExp Appl.* 97(2):203-210.
- Prakash YS, Bhadoria PBS, and Amitava R (2002) Relative efficiency of organic manures in improving resistance and pest tolerance of okra. *Ann. Agri. Res.*, 23: 525-531.
- Price JH, Dillon SD, Hodnett G, Rooney WL, Ross L, and Johnston JS (2005) Genome evaluation in the Genus Sorghum (Poaceae). *Ann of Bot.* 95(1): 219-221.
- Prudic KL, Oliver JC, and Bowers MD (2005) Soil nutrient effects on oviposition preference, larval performance, and chemical defense of a specialist insect herbivore. *Oecologia*, 143: 578-587.
- Piper C (1966) *Soil and Plant Analysis*. Asian Hans Publishers, Bombay, 11-36.
- Quintero JM, Fournier JM, Ramos JM, and Benloch M (1998) K⁺ status and ABA affect both exudation rate and hydraulic conductivity in sunflower roots. *Physiologia Plantarum* 102, 279-284.

- Ramesh P, Singh M, and Rao AS (2005) Organic farming: Its relevance to the Indian context. *Current Scientist*, Vol 88, No 4: 561-568.
- Ramzan M, Hussain S, and Akhter M (2007) Incidence of insect pests on sorghum crop under various nitrogen doses. *J. Anim. Pl. Sci.* 17(3-4)
- Rana BS, Rao VGM, and Rao NGP (1978) Genetic analysis of some Exotic X Indian crosses in sorghum XVIII. Breeding for resistance to grain deterioration. *Indian J. Genet.* 38 (3): 322-331.
- Rao M, and Gowda S (1967) A note on the bionomics and control of jowar fly. *Sorghum News lett.* 10: 55-57.
- Ravankar HN, Naphade KT, and Patil RT (1998) Long Term change in soil fertility status under sorghum ,wheat system on a vertisol.
- Saha NN, and Saharia D (1970) Effects pf dates of transplanting and levels of nitrogen on the incidence of stem borer, *Tryporyza incertulas* (Wlk) in paddy in Assam. *Indian J. Entomology.* 32(3): 225-229.
- Setamou M, Schulthess F, Bosque NA, and Thomas A (1995) The effect of stem and ear borers on maize subjected to different nitrogen treatments. *Ent. exp. Appl.*, 77: 205- 210.
- Shivayya V, Naik MI, and Ajithkumar MA (2009) Influence of different fertilizer levels on the incidence of major insect pests in maize. *Karnataka J. Agric. Sci.*, 22(3-Spl. Issue): (651-652).
- Sharma KN, and Rana DS (1980) Fertility status of a Jolewal lomy sand after six year of its use under nine multiple cropping system *J.Indian Soc.Soil.Sci.*28;173-177.
- Sing A, Sing B, and Vinod K(1998) Effect of organic manures and fertilizer doses on *kharif* sorghum of UP. *Indian J.*13(1);19-20.
- Singh YP, Baba B, and Pandey ND (1990) Chemical control of *Sesmia inferens* Wlk. In wheat crop. *Indian J. Entomology.* 52 (3): 431-434.
- Surekha J, and Rao PA (2001) Management of Aphids on bhendi with organic sources of NPK and certain insecticides. *Andhra Agric. J.*, 48: 56-60.
- Sweeny DW, Granade GV, Eversmeyer MG, and Whitney DA (2000) Phosphorous, potassium, chloride and fungicide effect on wheat yield and leaf rust severity. *J. Plant Nutr.*23 (9):1267-1281
- Tanzubil PB, Zakariah M, and Alem A (2006) Effect of nitrogen and farm yard manure on insect pests of pearl millet in northern Ghana. *Trop. Sci.*, 4: 35-39.

- Tanzubil P (2014) Effect of variety and nitrogen fertilization on insect pest incidence in *Sorghum* in the Sudan Savanna of Ghana. *Journal of Entomology and Zoology* 2014; 2 (6): 12-15
- Taley YM, Rajurkar BS, and Thakare GR (1981) Bionomics of *Atherigona soccata* (Rondani). *PKV Res. J.* 5(1): 62 - 68.
- Tetarwal AS, Sharma A, and Agarwal VK (2012) Effect of different nitrogen doses on the incidence of aphid (*Hyadaphis coriandri*). *Crop Res.*, 44: 203–204.
- Ujart SA, and Andrade F H (1995) Nitrogen efficacy in maize. Effect on crop growth, development, dry matter partitioning and kernel set. *Crop. Sci.*, 35:1376-1383.
- Wang Y (2001) Effects of different fertilization modes on the metabolism of wheat aphids. *J. Southwest Agric. Univ.*, 23: 255–256.
- Weibull J (1987) Seasonal changes in the free amino acids of oats and barley phloem sap in relation to plant growth stage and growth of *Rhopalosiphumpadi*. *Annu. Appl.Biol.* 111: 729-737.
- Yadav HS, and Alok kumar(1998) Integreted use of organic and inorganic fertilizer in rice ,wheat cropping system.
- Yardim EN, and Edwards CA (2003) Effects of organic and synthetic fertilizer sources on pest and predatory insects associated with tomatoes. *Phytoparasitica* 31 (4): 324-329.

VITA

1. Name of student : **Thakre Manoj Khandu**
2. Date of Birth : 01-06-1991
3. Name of college : Post Graduate Institute,
Dr. PDKV, Akola
4. Residential Address : Manik chouk, Matrutirth Sindkhed raja.
Tq. Sindkhed Raja
Dist. Buldhana.
Pin – 44 32 03
Mobile No. – 9421256568
Email-manoj.thakre7@gmail.com

5. Academic Qualification

Sr. No.	Name of degree awarded	Year in which obtained	Division / Class	Name of awarding university	Subjects
1	B.Sc. (Agri.)	2013	First	Dr. PDKV, Akola	Agriculture and Allied Science

6. Research paper published : Nil
7. Field of interest : Agricultural Entomology

Place: Akola

Date: 31/5/2016

M. Thakre

Signature of student

