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An Overview of Salt Affected Black Soils : Characteristics and Management

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ABSTRACT

Salinity and sodicity are prime threats to land resources resulting in huge economic and associated social consequences. Nutrient deficiencies reduce crop productivity in salt-affected regions. Soil fertility has not been sustainably managed in salt-affected semi arid regions. Soil degradation resulting from salinity, sodicity or a combination of both, is a major impediment to optimal utilization of soils. Salt affected soils exist mostly under arid and semi arid climates, in more than 100 countries. Agricultural production in the arid and semi arid regions is limited by salinity, sodicity, poor water resources, limited rainfall and loss in soil fertility, constrained to a localized area or sometimes extending over the whole of the basin. Extension of irrigation to the arid and semi arid regions, however, usually had led to an increase in the area under shallow water tables and to intensify and expanding the hazards of salinity and sodicity. This is because irrigation water brings in additional salts and releases immobilized salts in the soil through evapotranspiration and concentrating dissolved salts in the soil solution. The relative significance of each source in contributing soluble salts depends on the natural drainage condition, soil properties, ground water quality, irrigation water quality, and management practices.

Black soils:

Black soils (Vertisols and their intergrades) occur in many parts of the world. In India these soils occupy an area of 72.9 million hactares, 35.5 per cent of which is in the state of Maharashtra (Murthy *et al.* 1982). Majority of these soils occur in the lower piedmont plains or valleys and in micro depressions that are developed in the alluvium of weathered Deccan basalt (Pal and Deshpande, 1987).

Salt affected soils:

The salt affected soils occur in India, in association with the fertile soils of arid and semi-arid regions. The problem of salinity and sodicity in these areas is becoming more serious and is a matter of concern because of alarming increase in the area. According to the estimates, an area of about 6.73 m ha suffers from the problem of salt accumulation out of which 3.77 m ha are sodic while 2.96 m ha are saline soils (Sharma *et al* 2004). In India chemical degradation by salinization and alkalization is reported to be extended to 10.1 Mha and the problem is further increasing at an alarming rate (Suri, 2007).

Varade *et al.* (1985) reviewed the characteristics of salt affected Vertisols in canal commands and reported that approximately, 10 per cent of the irrigable Vertisols area in each irrigation project is affected due to salt and water logging problems. The salt affected Vertisols have been reported to have saline, saline sodic and sodic characteristics. The main cause of salt problems to Vertisols reported include unscientific irrigation, topographic situation, aridity in climate, ground water rise due to canal seepage and poor drainability.

Primary salinization:

Black soils are mainly confined to river valleys, one of which is Purna valley covering parts of the Amravati, Akola and Buldhana districts in Vidarbha region of Maharashtra. This valley is an oval shaped basin drained by the Purna river system. Even though the river Purna flows throughout the year, the soils along both banks have reported as being salt affected (Adyalkar, 1963). The very high clay content of these soils can be attributed to their formation from basaltic parent material (Pal and Deshpande, 1987). The earlier work carried out in the area (Magar, 1990; Nimkar *et al.* 1992; Kadu *et al.* 1993) indicated that many soils in this valley are non-saline, the EC being less than 2 $dSm^{-1}$and the ESP less than 15. However, these soils have not been categorized in appropriate class because they show deterioration at ESP values much lower than 15. They are prone to waterlogging and show severe problems of drainage. However these soils do not show any salt efflorescence on the surface (Pal, 2004).

The hydraulic conductivity (0.06 to 7.3 mm hr^{-1}) of the black soils of Purna valley observed by Magar (1990) was found to have significant negative correlation with exchangeable magnesium percentage (EMP). Considerable reduction in hydraulic conductivity with depth was observed in deep black soils of this region by

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Kadu *et al.* (1993) and Kadam *et al.* (2013). The value of COLE ranges from 0.18 to 0.28 cm cm^{-1}, indicating high swell shrink activities in these soils due to predominance of smectitic clay (Balpande *et al.* 1996). On the basis of categorization of COLE value, these soils fall into very high shrink swell soils (Nayak *et al.* 2006). An increase in ESP with depth is general observation for black soils in the semi- arid region of the peninsular India (Nimkar *et al.* 1992). The initiation of alkalinisation is operative in these soils in subsurface layers as a consequence of salt accumulation and its progress in upward direction alongwith capillary rise of soil solution during dry periods. Further, Balpande *et al.* (1996) in their studies pointed out that the development of sodicity in soils of South-Western part of valley has been attributed to the semi arid climate conditions that have induced the pedogenic process of calcium carbonate thereby resulting in an increase of both SAR and ESP with pedon depth. They also reported that the lower hydraulic conductivity of these soils is related to ESP more than 5 and exchangeable Ca/Mg ratio. Padole *et al.* (1998) studied bulk density of these soils (1.28 to 1.88 Mgm^{-3}), reported typically low hydraulic conductivity (5.2 to 1.7 mm hr^{-1}), and high CEC (more than 42.3 cmol(p^{+})kg^{-1}). The pHs, ECe, ESP of these soils ranged between 7.3 to 9.6, 0.90 to 5.74 dSm^{-1} and 2.57 to 33.78, respectively. They further reported that the hydraulic conductivity of these soils is adversely affected by soil attributes such as clay and smectite content, bulk density, exchangeable sodium percentage (ESP) and sodium adsorption ratio (SAR).

Studies on polygenetic Vertisols in this valley by Pal *et al.* (2001) revealed that the soils of southwestern part are strongly alkaline with ESP of 5-26 and in northeastern part are moderately alkaline and have ESP values <5. The soils have both pedogenic and non pedogenic calcium carbonate. The lack of soil water in the soils of southwestern area is thought to be the reason for weak swelling of smectite, for larger amount of pedogenic carbonate and for cracks cutting through the slickenside zone. Kadu *et al.* (2003) reported that these were impoverished with respect to organic carbon and calcium was a dominant exchangeable cation. In general exchangeable Ca decreases while exchangeable Mg increase with depth. They further reported, significant positive correlation between hydraulic conductivity and exchangeable Ca/Mg ratio and significant negative correlation between HC and ESP of the soils suggesting that the hydraulic properties of the soils impaired initially by Mg, which were further aggravated by Na. Kadam (2011) in his studies on the decadal change in soil degradation in Purna valley observed that there has been increase in the pH along with ESP of these soils over a period of time under the prevailing climate.

Kharche *et al.* (2012) ascertained the soil degradation in Vertisols of Purna valley and pointed out that despite low levels of sodicity (ESP 4.8-11.1), the soils had severe drainage problems because of low hydraulic conductivity. Similarly it was also noticed that high amount of smectite clay leads to increase in bulk density and thus results into hard and compact soil structure. The soil pH ranged from (7.0 to 9.5), ECe (0.44 to 2.74) dS m^{-1} and ESP (4.8 to 11.1) which increased in subsoil. The soils are reported to be calcareous in nature with a tendency to increase calcium carbonate with depth. This may be due to semi-arid climatic condition, where the leaching of bicarbonates during rainy season from upper soil horizons and its subsequent precipitation triggers development of sodicity in subsoils of black soils. The bicarbonates precipitated in subsoil indicated operative alkalinisation under semi-arid conditions. The subsoil sodicity also leads to downward decrease in mean weight diameter. The soils showed poor internal drainage even at the ESP values much lower than 15 ESP (Kadam *et al.*, 2013). Pal et al (2012) reported that these Vertisols of dry climates have poor drainage, but they show no salt-efflorescence on the soil surface as evidence of the threat of soil sodicity. These soils also do not qualify as salt-affected soils as per the United States Salinity Laboratory criteria; however, the sHC of their sub-soils is adversely affected by clay dispersion caused by exchangeable magnesium. This point suggests that the saturation of Vertisols, not only with Na^{+} ions but also with Mg^{2+} ions, blocks small pores in the soil. Biological properties of these soils (Mane, 2012) were adversely affected by salinity and sodicity and soil microbial biomass carbon and soil respiration were decreased with increasing salinity and sodicity. Salinity influenced soil enzyme activity (dehydrogenase, urease) negatively. The microbial population viz: bacteria, fungi and actinomycetes were decreased with increase in salinity of soils in Purna valley.

Secondary salinization:

The most predominantly occurring black swell shrink soils in the canal command areas of Maharashtra pose severe problems of salinity and sodicity due to indiscriminate use of irrigation water coupled with

monocropping of crops like sugarcane and increasing aridity of climate. The problem is further aggravated due to very high clay contents of soils with slow permeability and restricted drainage causing impairment in soil quality and serious reductions in crop yields. The soils of Mula canal command area in Ahmednagar district which were normal before introduction of canal (Somawanshi and Patil, 1986) are now suffering from degradation due to salinity and sodicity (Durgude, 1999 and Kharche *et al.* 2004). Several workers indicated the irrigation induced soil degradation causing serious soil quality deterioration in Mula (Kharche and Pharande, 2010) and Godavari (Dongare, 2010) command areas in Maharashtra which warrants the immediate attention for their reclamation and management.

Irrigation induced Sodic Vertisols in Mula command in Ahmednagar district of Maharashtra were studied by Kharche *et al.* (2004) and they concluded that severity of salinity and sodicity in these soils is being further aggravated by semi-arid climate, indiscriminate use of irrigation water and restricted drainage. The soil reaction was moderately to strongly alkaline with variable pH in different horizons. The soils were calcareous with a high $CaCO_3$ (9.5 to 16.2 per cent). The high pH more than 9.0 was recorded in some soil horizons. The ECe was more than 4dSm^{-1} (4.84 to 13.89 dSm $^{-1}$) and ESP was high through different horizons (14.3 to 23.1) and showed slight increase with increasing depth. Dongare *et al.* (2010) assessed land degradation in Godavari command and reported more severity of degradation due to salinity-sodicity hazards in the lowland compared to upland. The serious decline in hydraulic conductivity is caused due to very high clay content of smectitic nature coupled with low Ca/Mg ratio and high exchangeable sodium and magnesium. As per the U. S. Soil Salinity Laboratory criteria only about 19 per cent soils were found to be degraded while as per the kind and degree of land degradation assessment criteria proposed by them almost 98 per cent soils were categorized as saline-sodic. The yield of sugarcane was negatively correlated with ESP (r = -0.63**) and ECe (r = -0.38**) while wheat yield also showed close negative relationship with ESP(r = -0.39**) and ECe (r = -0.42**). This suggests that the criteria of ESP for sodic soils need to be modified.

Management of Salt Affected Soils:

Conventional and Innovative Approaches

Management of salt affected Vertisols with subsurface drainage and crop residue incorporation has been studied by Bharambe *et al.* (2001) under soybean-wheat cropping system on sodic Vertisol. Soil reaction and electrical conductivity was decreased from 8.26 to 8.20 and 2.45 to 2.25 dS m^{-1}, whereas organic carbon content increased from an initial value of 6.4 to 7.3 g kg^{-1} with crop residue application, highest being under green manuring with dhaincha. The physical properties were improved and salinity and sodicity of soil reduced considerably below critical limit of salinity hazards with incorporation of crop residue such as sugarcane trash @ 5 t ha^{-1} or green manuring with dhaincha over a period of four years. Sagare *et al.* (2001) in their studies on effect of land configuration and gypsum levels on dynamics of soil properties and productivity of cotton grown in sodic Vertisol revealed that a significantly highest reduction in pHs, ECe, SARe and ESP was noticed due to incorporation of gypsum @ 100 per cent GR. The interaction effects between land treatments (opening of furrow after two rows of cotton) and gypsum levels in reducing ECe, ESP and SARe was significant. The significant increase in HC of sodic Vertisol was observed due to gypsum @ 100 per cent GR over gypsum @ 25 per cent GR.

Soil fertility and productivity:

The recommendations for application of amendments in sodic black soils of Purna valley have been made based on the increase in the crop yield and soil improvement. Broadcasting of gypsum in powder form @ 2.5 t ha^{-1} (50% GR) before sowing of crop and mixing it with surface soil is recommended for increasing the productivity of cotton, sorghum and greengram as well as improving the physical and chemical characteristics of sodic soils of Purna valley (Sagare *et al* 2000). For improving the characteristics of soil and sustaining the yields of greengram –saffower on sodic Vertisols of Purna valley, it is recommended to incorporate crop stubbles @ 2 t ha^{-1} + PSB @ 10 kg ha^{-1} alongwith 50 per cent recommended dose of fertilizers.

Soil amendments availability : constraints and alternative sources:

The gypsum which was widely used amendment in these soils is also becoming scarce and needs to be supplemented with alternative amendments. The spent wash press mud compost (SWPMC) obtained from sugar factories in these areas is locally available and cheap potential alternative amendment which has been used for reclamation in conjunction with gypsum by Kharche *et*

al. (2010) in their field experiments to study the effect of gypsum and SWPMC along with bio-inoculants on properties of sodic soil on research farm, MPKV, Rahuri and reported that application of gypsum @ 25 per cent GR along with 10 Mg SWPMC ha^{-1} significantly reduced the soil pHs from 8.65 to 8.14, ECe from 2.93 to 2.30 dS m^{-1} and ESP from 18 to 11.4. The integrated use of amendments was found beneficial for improvement in physical properties of soils *viz.*, bulk density (from 1.40 to 1.23 Mg m^{-3}) and hydraulic conductivity (0.45 to 0.81 cm h^{-1}). The significant improvement in dehydrogenase (DHA) activity was recorded under integration of gypsum and SWPMC along with application of bio-inoculants which supply organic carbon that act as feed for microbes thereby increasing DHA.

Belur (2006) observed gradual changes in physical properties of sodic soils of Maharashtra. Bulk density decreased while hydraulic conductivity increased due to gypsum as well as its combined use with SWPMC. Hydraulic conductivity was improved from 0.45 to 0.81 cm h^{-1} during reclamation. Replacement of sodium due to addition of gypsum gradually helped in flocculation process resulting in better aggregation, which causes decrease in bulk density and improvement in hydraulic conductivity of soil. The reduction in bulk density was also due to regeneration of structure caused by improved aggregation with the addition of organic matter present in compost. This suggests that the integration of chemical amendment and organic conditioner along with bio-inoculants was found more beneficial in improving air-water relationship in sodic soils.

Sagare *et al.* (2001) also reported the lower extent of increase in hydraulic conductivity of sodic Vertisols from 0.41 to 1.05 cm h^{-1} due to gypsum. Kharche *et al* (2010) further revealed that the added advantage of increase in hydraulic conductivity observed in their study under the combined use of compost with gypsum can be ascribed to the dissolution of calcite which releases more calcium in addition to the calcium from gypsum causing flocculating effect. Use of compost improves the efficiency of reclamation of calcareous cracking clay sodic soils and also can act as an alternative to gypsum. The significant reduction in ESP by the combined application of gypsum and SWPMC is attributed to more effective reclamation as enhanced by SWPMC which acts as an ameliorant in calcareous sodic soil where the organic matter in SWPMC on its decomposition produces organic acids solubilizing native calcium carbonate resulting into faster removal of exchangeable sodium and accelerates the reclamation of calcareous sodic soil.

Sonune *et. al.,* (2011) carried out a field investigation on farmer's field to evaluate the gypsum bed technique for irrigating cotton in sodic Vertisols of Purna valley. Results indicated that soil application of gypsum @ 25 per cent GR + surface irrigation with alkali water after passing through 30 cm gypsum bed sustained the seed cotton yield with higher B:C ratio. This combination further reduced the detrimental characteristics like pHs, ECe, SAR, ESP and also improved HC of soil significantly over control. They have studied cotton productivity and soil characteristics as influenced by alkali water irrigation and found that soil application of 25 per cent GR and passing alkali water through 30 cm gypsum bed recorded 56.5 per cent seed cotton yield increase over control. Seed cotton yield showed significant positive correlation with exchangeable Ca and Ks and negative with SAR and ESP. Installation of sub surface drainage at 75 m spacing with 80 mm diameter PVC corrugated pipe in saline alkali deep Vertisol with incorporation of sugarcane trash @ 5 tha^{-1} or green manuring with dhaincha provided effective drainage and significantly increased the productivity of soybean and wheat by the reclamation of the saline alkali soil (Bharambe *et al* 2001). The effective alternatives to the conventional approaches are necessary to increase the potential of soil reclamation. Application of organic amendments in the form of green manures and crop residues is the simple practice which can prove as promising option in this regard.

Field experiments to study the effect of various organic amendments in comparison with gypsum on carbon dynamics and nutrient availability in calcareous sodic Vertisols of Purna valley (Shirale, 2014) revealed that application of organic amendments significantly enhanced the organic carbon, permanganate oxidizable carbon, soil microbial biomass carbon and SOC stock over the application of gypsum and control. The application of dhaincha and sunhemp in situ green manuring showed highest potential to sequester carbon in soils. The potential of different organic amendments in alleviating the carbon and nutrient stress in sodic Vertisols under high pH and ESP stress situation besides reclamation has been documented.

Carbon sequestration in salt affected soils:

Wong *et al.* (2009) studied carbon fluxes in sodic and saline soils by measuring the soil microbial biomass carbon and soil respiration rates in Australia, comprising of treatment gypsum (10 t ha^{-1}) and organic material, as kangaroo grass (10 t ha^{-1}). Cumulative soil respiration rates were lowest in sodic and saline soils without amendments, while the highest rates were found in those soils that had organic material addition. The addition of gypsum decreased cumulative respiration rate in 0-5 cm layer compared to addition of organic material and gypsum. Similarly, the soil microbial biomass carbon (SMBC) was lowest in sodic and saline soils without amendments and highest in the soils which had organic material addition, while effect of gypsum addition were not significant. The lowest levels of respiration and SMBC were attributed to the low soil organic carbon (SOC) levels that resulted from little or no C input into the soils of these highly degraded landscapes. Following addition of organic material to sodic and saline soils, SMBC levels and respiration rates increased despite adverse soil environmental condition. Recently, Shirale (2014) observed that the organic amendments viz. dhaincha, sunhemp, cowpea, leucaena loppings, green gram, cotton stalk were found to improve the SOC stock in comparison with gypsum indicating their potential for carbon sequestration in addition to gradual chemical reclamation of soil. The low status of carbon stock in sodic soils offers immense scope for increasing carbon stock in degraded soils in present climatic change scenario. Present day changes in climate are likely to influence rates of accumulation and decomposition of soil organic carbon, both directly, through changes in temperature and moisture, and indirectly through changes in plant growth and rhizodeposition. Hence, it is very essential to adopt such soil restorative and environment friendly practices in sodic soils.

Categorization of saline sodic black soils:

The smectitic clay in black soils in combination with high exchangeable sodium results in high degree of shrink swell potential which causes the problems of internal drainage thereby adversely affecting crop production. As an effect of climate change the rainfall has been observed to gradually decrease over a period of time in this area and the rainy days are drastically reduced with prolonged dry spells coupled with increase in temperature. This is causing further increase in soil degradation and there has been increase in pH in subsoil associated with increase in ESP towards lower horizons with concomitant decrease in exchangeable Ca/Mg ratio (Kharche *et. al.,* 2012).

Australian worker, who attach great importance to the deterioration of soil physical condition and its harmful effect on plant growth, consider ESP is too high to differentiate sodic soils from non sodic in case of swell shrink heavy clay soils. Northcote and Skene (1972) proposed ESP 6 as a limiting value to indicate sharp impairment of physical condition. Kharche and Pharande (2010) observed that these soils even with comparatively lower ESP in association with high clay content of smectitic nature show the problems in drainage. They have documented that this was supported by the farmers' experience in the area and also field observations in the form of reduction of mottles in soil profile and conditions of poor drainage even at ESP 10. They indicated the necessity of lowering the ESP limit in black swell-shrink soils for categorizing them as sodic mainly because the sodification problem in these soils is further aggravated by the high clay content causing the soils to be inherently slow in permeability. The threshold value of 15 ESP for a soil to be termed sodic is not sacrosanct and soil physical properties could deteriorate at values lower than this (Swarup, 2004). An ESP limit of 5 has been suggested by Balpande *et al.* (1996) for alkali subgroup of Vertisols in central India that have high smectite content. Sharma *et al.* (1997) reported that an ESP of 5 and 6 in Vertisols could cause considerable deterioration in soil physical properties. Pal *et al.* (2006) advocated a value of sHC less than 10 mm h^{-1} instead of ESP or SAR. As regards their management therefore, improving drainage porosity is most crucial. In this view several workers viz. Kharche and Pharande (2010), Dongare (2010), Kadam *et al.* (2012), Pal *et al.* (2012) and Shirale (2014) based on their data on soil quality attributes in relation to crop yields and local field experience advocated that, the current lower limit of a 15 ESP by the United States Salinity Laboratory for all soils is arbitrary and necessitates the evaluation of a lower ESP limit for saline sodic black soils. However, further investigations on the extent of dispersion due to different degrees of sodium and its effect on soil quality in relation to crop yield reduction particularly in Vertisols are necessary.

To sum up, the soil chemical degradation in terms of increase in ESP and EMP with depth in black swell shrink soils adversely affects the hydraulic and other

properties important for crop growth. These soils contain high $CaCO_3$ and the precipitation of Ca in the form of $CaCO_3$ immobilizes Ca and Mg and dominance of Na is increased, which affect physico-chemical properties of soil adversely. This causes clay dispersion, leading to destabilization of soil structure, breaking of soil capillary network and ultimately affecting water transmission characteristics of the soil. The ESP limit of USSL at 15 is quite high and needs to be reduced in view of deterioration in physical properties of soils. Crop residues and green biomass addition to black saline sodic soils in comparison to only gypsum is beneficial to enhance the soil organic carbon stock and soil quality besides helping in gradual soil reclamation.

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Stability Studies in Wheat Genotypes for Irrigated Ecosystem in Maharashtra

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ABSTRACT

Multilocation experiment was conducted at Akola, Niphad and Parbhani in Maharahstra during *Rabi* 2014-2015 with thirteen genotypes. Analysis revealed that environment and (G x E) differences were highly significant for days to maturity and straw yield kg plot^{-1}. While, plant height (cm) and tillers sq.m.$^{-1}$ depicted significant differences among the environments and their interaction with the genotypes. The environment alone was highly significant for tillers sq.m^{-1}, days to maturity and grain yield kg plot^{-1} thereby indicated the differences between environments selected for study. While G E interaction was highly significant for days to maturity, plant height (cm) and straw yield kg plot^{-1} characters only. The environment linear component was highly significant for 7 characters viz., days to heading and maturity, plant height (cm), effective tillers plant^{-1}, tillers square^{-1} meter, grain yield kg plot^{-1} as well as straw yield kg plot^{-1} indicating the significant differences among the environments. While, G x E linear component was highly significant for days to maturity, plant height (cm) and straw yield kg plot^{-1}only. Results revealed that genotypes MWL 1683, MACS 1684 and NIDW 295 showed high stability for grain yield and other characters studied. Genotype MWL 1683 proved to be the best within the pool of genotypes for yield and its contributing traits; however its evaluation for quality traits is essential.

The development of improved genotypes, which can be adapted to a wide range of environments, is one of the final goals of researchers in plant breeding program. The interplay between the effects of genotypes and environments is usually known as genotype x environment (GE) interaction (Moll and Stuber, 1974). The G xE interaction is an important restricting factor in the estimation of variance components as well as in the efficiency of selection programs. The adaptability of a genotype over diverse environmental conditions is tested by the magnitude of its interaction with different locations and over several years (Baker, 1988). A genotype is considered to be more favorable one, if it has a high mean yield with low amount of fluctuations. The GE interaction reduces the correlation between genotype and phenotype and reduces the effectiveness of selection (Flores *et al.* 1998). The presence of a GE interaction for seed yield as a quantitative trait can decrease the usefulness of subsequent analysis, restrict the significance of inference and seriously limit the feasibility of selecting favorable genotypes (Sabaghnia *et al.* 2008) Selection of stable genotypes, which perform consistently better across the environments, can reduce the magnitude of GxE interaction.

Many methods have been established to measure the stability and the G x E interaction. Out of these models the most simple and popular one is Eberhart and Russell (1966) was utilized for the present study.

MATERIAL AND METHODS

The present investigation was carried out at three environments viz., Akola, Parbahni and Niphad. Research experiment was laid out in Randomized Block Design having three replications with gross plot size of 14.4 m^2 .Wheat seed was drilled in 12 rows of 6 m row length spaced at 20cm apart during *rabi* season 2014-2015. Recommended agronomical practices were followed for raising the healthy crop. Thirteen genotypes viz., Ankur Umesh, NIDW 295 (DC), RIL-3, Swarnim Sima, MWL 1683, Pranshu, MACS 6478 (AC), RIL-10 (D), Prerna Vardan, Ankur Yogesh, Swarnim Surya, Ankur Shivraj, Super-111were tested at three environments. The study was based on 10 quantitative characters viz., days to heading, days to maturity, plant height (cm), effective tillers plant^{-1}, tillers sq.m.$^{-1}$, spike length (cm), grains spike $^{-1}$, 1000 grain weight (g) and grain yield kg ha^{-1}

Individual environment and pooled data was subjected to Analysis of Variance (Panse and Sukhatme, 1967). The traits which showed significant G x E interaction were analyzed using the Eberhart and Russell Model (1966). As per model, three parameters viz., overall mean performance of each genotype across the

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environments (Xi), the regression of each genotype on the environmental index (bi) and squared deviation from the regression were estimated (s^2di). The significance of stability parameters and devotions from unity were tested by student's 't' test.

RESULTS AND DISCUSSION

i) Mean performance

Data depicted in Table 1, revealed that three environments (Akola, Niphad and Parbhani of Maharahstra) exhibited significant differences for all of the characters. Mean performance of grain /spike was found superior at E1 location, whereas E2 was found better for most of the characters viz., days to heading and maturity, plant height (cm), effective tillers plant^{-1}, tillers sq. m.$^{-1}$, spike length (cm) and grain yield kg ha^{-1}. While, in E3 only two1000 grain wt. and straw yield kg ha^{-1} were found significant (Table 1).

ii) Stability

Analysis of variance for stability analysis (Table 2) revealed that the genotypic differences pooled over three environments were highly significant for plant height, effective tillers plant^{-1}, spike length, grain spike^{-1}, 1000 grain weight and straw yield kg ha^{-1}, indicating the presence of sufficient amount of variability for these characters among the genotypes and for rest of the characters the genotype are at par with each other.

Environment and (G E) mean sum of square are significant for days to maturity, plant height (cm), tillers sq.m.$^{-1}$ and straw yield kg plot^{-1} indicating significant difference among the environments and their interaction with the genotypes. Whereas, mean sum of squares due to environment alone were significant for days to heading and maturity, tillers sq.m.$^{-1}$, effectives tillers, grain and straw yield kg plot^{-1}. While due to G E interaction source sum of squares were highly significant for days to maturity, plant height (cm) and straw yield kg ha^{-1} characters only and for rest of the characters mean sum of squares due to G E interactions are non- significant.

The environment linear component was highly significant for 7 characters out of 10 which included days to heading and maturity, plant height (cm), effective tillers plant^{-1}, tillers sq.m.$^{-1}$, grain as well as straw yield kg ha^{-1}. While the G E linear component was highly significant for days to maturity, plant height (cm) and straw yield kg ha^{-1}.

An ideal genotype is defined as, genotype possessing high mean performance for particular character with regression coefficient close to unity (bi=1) and deviation from regression as good as to zero (S^2di =0). In present investigation on the basis of mean grain yield and stability parameters together genotype MWL 1683 exhibited stable performance over environments with average mean yield (2958 kg/ ha), regression co-efficient value (bi= 1.069) and minimum deviation from regression (S^2di = -23.6), followed by MACS 6478 which exhibited average yield of 3069 kg ha^{-1} regression co-efficient (bi= 1.142) and minimum deviation from regression co-efficient (S^2di = -31.9).

Ankur Umesh with mean yield (2910 kg/ha) regression co-efficient value (bi= 0.159) and deviation from regression (S^2di = 93.1) and RIL 3 with mean grain yield (2931 kg/ha) regression co-efficient value (bi= 0.478) and deviation from regression (S^2di= -30.6) were proved to be adapted to unfavorable environment. Whereas, genotypes NIDW 295 (DC) with mean yield (3056 kg/ha) regression co-efficient value (bi= 1.439) and deviation from regression (S^2di =66.7) and Pranshu with grain mean yield (2750 kg/ha) regression co-efficient value (bi= 1.742) and deviation from regression (S^2di = 22.9) proved adapted to favorable environment.

In respect of other quantitative characters considering three parameters together i.e. mean regression coefficient value and deviation from regression, genotype NIDW 295 (DC) for days to heading and maturity, genotype Super 111 for tillers sq.m^{-1} and Swarnim Surya and Prasnhu for spike length. While, genotypes RIL 3 and Pranshu were specifically adopted for rich environment for grains spike^{-1} character. Similarly for 1000 grain wt. character RIL10 (D) and MWL 1683 are the stable genotypes and for straw yield kg ha^{-1} Ankur Shivraj and Swarnim Surya are proved to be stable. These findings were in close agreement with Gohil and Jadeja (2009), Haman and Khaled (2009), Gowda et al. (2010) Mohmadi Reza et al. (2010) and Najafian *et al.* (2010).

Gohil and Jadeja (2009) reported that none of the genotype was stable for evaluated traits; however genotypes depicting stable performance for yield gram plant^{-1} offered the possibilities of exploitation for varietal development program in wheat.

Therefore it is concluded that the genotypes MWL 1683, MACS 1684 and NIDW 295 showed stable

Table 1: Mean, Range and Environmental index (EI) for eleven (11) quantitative traits in wheat

S.N.	Character	E_1			E_2			E_3		
		Mean	Range	EI	Mean	Range	EI	Mean	Range	EI
1	Days to heading	56.30	51-63	0.632	54.51	51-60.66	-1.162	56.20	52-60	0.532
2	Days to maturity	111.64	107.76-114	2.667	103.05	101-106.66	-5.923	112.23	109.33-115	3.256
3	Plant height(cm)	83.48	71.33-89	1.735	80.64	73.33-84	-1.111	81.12	71.33-89.33	-0.624
4	Tillers sq.m.$^{-1}$	95.17	63.33-118.33	-9.821	126.38	115.66-142	21.38	93.43	68.33-105.33	-11.56
5	Effective tillers plant^{-1}	4.003	3.20-5.43	-0.077	4.37	3.13-5.63	0.297	3.85	3.13-4.90	-0.221
6	Spike length(cm)	8.01	7.16-8.53	-0.074	8.14	7.36-8.6	0.055	8.10	7.56-8.66	0.019
7	Grains spike^{-1}	44.94	40.33-53.00	-0.009	44.51	38.33-51.00	-0.444	45.41	40.66-54.00	0.453
8	1000 grain weight (g)	41.25	36.3-46.2	-0.458	41.84	37.96-44.96	0.13	42.03	39.46-45.13	0.328
9	Grain yield kg plot^{-1}	3.41	1.84-4.8	-0.725	4.83	4.33-5.79	0.697	4.16	2.92-4.69	0.028
10	Straw yield kg plot^{-1}	10	8.66-11.66	-1.376	11	9.33-12.33	-0.376	13.12	9.33-15.33	1.752

E1- Akola E2- Niphad E3- Parbhani

Table 2: Analysis of variance for stability analysis

Sources	df	Days to heading	Days to maturity	Plant height (cm)	Tillers/sq meter	Effective tillers/plant	Spike length (cm)
		1	2	3	4	5	6
Rep within Env.	6	1.425	1.382*	3.043	41.433	0.011	0.022
Varieties	12	26.787**	5.081**	75.094**	211.142	0.912**	0.259**
Env.+ (Var.* Env.)	26	4.496	27.906**	29.407*	472.593*	0.216	0.061
Environments	2	13.208*	343.188**	30.122	4468.573**	0.930*	0.057
Var.* Env.	24	3.770	1.632**	29.348*	139.594	0.156	0.061
Environments (Lin.)	1	26.416**	686.376**	60.245*	8937.146**	1.859**	0.114
Var.* Env.(Lin.)	12	4.989	2.774**	49.069**	134.741	0.136	0.058
Pooled Deviation	13	2.354	0.454	8.887*	133.336**	0.163**	0.059
Rep within Env.	72	2.810	1.160	4.037	31.652	0.049	0.041

Sources	df	Grains/spike	1000 grain weight(g)	Grain yield kg/ ha	Straw yield kg/ ha
		7	8	9	10
Rep within Env.	6	1.043	0.442	0.032	0.140
Varieties	12	41.448**	10.584**	0.184	1.818*
Env.+ (Var.* Env.)	26	2.419	2.213	0.908	4.009**
Environments	2	2.618	2.169	6.573**	33.182**
Var.* Env.	24	2.402	2.217	0.436	1.577*
Environments (Lin.)	1	5.236	4.337	13.146**	66.365**
Var.* Env.(Lin.)	12	3.061	2.458	0.418	2.553**
Pooled Deviation	13	1.609	1.823	0.418**	0.555
Pooled Error	72	3.441	1.022	0.048	0.522

** Significant at 1% probability level, *Significant at 5%

Table 3: Stability parameters for germination %, days to heading, Days to maturity, plant height, tillers/sq. meter and effective tillers/plant

S.N.	Genotypes	Days to heading			Days to maturity			Plant height			Tillers/sq. meter			Effective tillers/plant		
		1			2			3			4			5		
		Mean	b_i	S^2d_i	Mean	b_i	S^2d_i	Mean	b_i	S^2d_i	Mean	b_i	S^2d_i	Mean	b_i	S^2d_i
1	Ankur Umesh	53.56	-2.442	-0.529	106.1	0.813	-0.469	81.78	0.64	-1.113	115.4	1.241*	-32.280	3.79	1.474	-0.013
2	NIDW 295 (DC)	61.56	0.813	-0.862	111.2	1.000	-0.595	80.89	0.08	-3.915	109.7	0.373	256.60**	4.86	1.608**	-0.045
3	RIL-3	55.00	2.633	-0.569	109.2	0.432**	-1.173	84.22	0.32	-3.248	97.6	1.557	-10.450	3.89	2.419*	-0.044
4	Swarnim Sima	56.00	2.498	2.611	108.3	1.013	-1.174	82.33	-0.34	-3.604	100.4	0.859	158.08*	3.69	-0.411	-0.022
5	MWL 1683	55.89	3.934	-2.525	110.1	0.806*	-1.166	87.44	1.15	7.721	114.7	0.674	-27.40	4.03	0.235	0.148 *
6	Pranshu	52.67	1.398	-1.063	107.4	1.088*	-1.176	74.56	-1.32	5.772	87.1	1.979	3.384	3.50	0.544	0.060
7	MACS 6478(AC)	57.89	1.385	-0.973	109.9	1.268	- 0.173	77.44	-1.42	23.45 *	96.8	0.893	832.98**	3.42	-0.533	0.307 **
8	RIL-10 (D)	61.11	0.743	1.581	109.6	1.167	-0.967	82.44	0.37	-3.613	113.0	1.100	150.06*	5.32	1.238	0.022
9	Prerna Vardan	52.89	0.536	-0.101	108.2	1.159	-0.942	72.00	-0.48	-2.359	98.6	1.173	35.265	3.67	0.739	0.222 *
10	Ankur Yogesh	53.89	0.956	4.401	109.4	1.088*	-1.176	83.78	2.52	35.517**	106.6	0.423	-30.254	4.30	0.596	0.079
11	Swarnim Surya	56.56	-0.137	-1.334	108.2	1.047	-0.985	91.22	11.28	13.46 *	105.9	0.672	9.664	3.82	1.157	0.530 **
12	Ankur shivraj	54.33	1.161	-2.553	109.4	1.266	0.086	81.89	0.56	-1.780	111.1	1.108	-21.166	4.33	2.83	-0.009
13	Super-111	52.44	-0.468	-2.630	109.4	0.853	0.514	82.78	-0.36	-2.246	108.2	0.948	-12.391	4.41	1.103	0.292 **
	Population mean	55.67			109			81.75			105.0			4.08		

Table 3 contd.. : Stability parameters spike length, grains/spike, 1000 grain weight (g), grain yield kg plot^{-1} and straw yield kg/plot

S.N	Genotypes	Spike length(cm)			Grains spike^{-1}			1000 Grains weight(g)			Grain yield (kg ha^{-1})			Straw yield (kg ha^{-1})		
		6			7			8			9			10		
		Mean	b_i	S^2d_i	Mean	b_i	S^2d_i	Mean	b_i	S^2d_i	Mean	b_i	S^2d_i	Mean	b_i	S^2d_i
1	Ankur Umesh	7.37	2.11	0.001	40.22	2.553	-0.030	41.04	-0.759	2.297	2910	0.159	93.1	8722	0.637*	-341.7
2	NIDW 295 (DC)	8.31	0.482	-0.027	45.00	2.589	-3.066	41.44	0.536	0.820	3056	1.439	66.7	7715	0.392	88.9
3	RIL-3	8.32	-3.413	-0.0073	46.33	1.528	-0.641	40.79	3.149	0.635	2931	0.478	-30.6	8722	1.463	148.6
4	Swarnim Sima	8.20	-4.181	-0.005	41.56	4.442	-2.9072	44.09	-4.461	-0.852	2924	0.496	201.4**	8799	1.503	-330.6
5	MWL 1683	8.11	5.23	-0.006	42.89	-1.818	-0.957	40.27	0.933	2.572	2958	1.069	-23.6	7944	1.961	-190.3
6	Pranshu	8.11	0.775	-0.030	41.67	2.186	-0.513	44.53	-0.406	0.583	2750	1.742	22.9	7333	0.711	77.1
7	MACS 6478(AC)	8.11	1.439	0.143 *	49.11	3.727	-3.001	43.54	4.202	-0.421	3069	1.142*	-31.9	7868	1.356	1162.5*
8	RIL-10 (D)	7.64	-0.339	-0.013	44.33	-4.074	-3.0530	44.01	0.792	0.202	2750	1.602	231.9**	7715	1.34	-174.3
9	Prerna Vardan	8.01	3.843	-0.039	41.78	-1.811	-0.058	42.27	-2.324	3.169*	2812	1.379	351.4**	7333	1.528	-234.7
10	Ankur Yogesh	8.29	2.449	-0.037	47.00	-1.082	-1.728	39.76	2.36	-0.892	2896	1.365	1674.9**	8028	1.315	56.2
11	Swarnim Surya	7.99	1.062	0.0003	42.67	-1.91	0.830	38.34	5.037	0.747	2451	1.787	699.3**	7715	0.792	-47.9
12	Ankur shivraj	8.21	1.361	0.265 **	49.22	3.338	-3.227	40.64	0.059	1.566	2764	0.577*	-31.9	7174	0.825	174.3
13	Super-111	8.44	2.182	0.0129	52.67	3.331	-3.060	41.52	3.882	0.5632	3083	-0.235	133.3*	7639	-0.825	174.3
	Population mean	8.08			44.95			41.71			2873			7901		

performance for grain yield and most of the character studied.

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Effect of Plant Growth Regulators on Andrographolide of Kalmegh *Andrographis paniculata* (Burm.f.)

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ABSTRACT

The present study was aimed at improving the content of therapeutically active principle, andrographolide and whole plant biomass of *Andrographis paniculata* (Burm. F.) Wall.Ex Nees, by foliar application of plant growth regulators during *Kharif* 2013 and *Kharif* 2014 at AAU, Anand. The experiment consisted the treatment *viz.* NAA @ 100, 200 mg $l^{-1}$and GA_3 @ 50, 100 mg l^{-1}. Foliar application was done at 45 days after transplanting (DATP). The LC-MS/MS analysis revealed that, application of NAA @ 200 mg l^{-1} was very effective to enhance the andrographolide content (2.31%), which was followed by NAA-100 mg l^{-1} (2.25%) over control at 90 days after transplanting. The whole plant biomass (Panchang) of *Andrographis* is used in medicine and hence dry biomass was also determined. The results indicated that NAA @ 200 mg l^{-1} (Dry Weight: 112.39 g $plant^{-1}$) and 100 mg l^{-1} (Dry Weight: 105.04 g $plant^{-1}$) at harvest emerged out as the best treatments for improving dry biomass over control. The treatments of NAA (200 mg l^{-1}) was found to be most effective for improving whole plant biomass as well as andrographolide content which can be recommended for the growers.

Among the different medicinal plants, *Andrographis paniculata* (Burm.f.) Wall. ex Nees is a herbaceous plant in the family Acanthaceae, native to India and Sri Lanka is one of the important species, which is now recently introduced for cultivation. The Isle of France is the origin of kalmegh (Kurian and Sankar, 2007). In India, it is occasionally in cultivation in plains of Uttar Pradesh, Madhya Pradesh, Chattisgarh, West Bengal, Karnataka, Deccan, Assam, Gujarat and Kerala. It is widely cultivated in Southern Asia, where it is used to treat infections and some diseases, often being used before antibiotics were created. Mostly the Panchang (whole plant parts) were used for medicinal purposes. *Andrographis paniculata* is an erect annual herb extremely bitter in taste in all parts of the plant body. The major bitter constituent in kalmegh is due to the presence of diterpene lactone called andrographolide (Raina, *et al.* 2013). The plant is known in north-eastern India as Maha-tita, literally "king of bitters", and known by various vernacular names. As an Ayurveda herb it is known as kalmegh or kalamegha, meaning "dark cloud". It is also known as Bhui-neem, meaning "neem of the ground", since the plant, though being a small annual herb, has a similar strong bitter taste as that of the large neem tree (*Azadirachta indica*).

Plant growth regulators (PGRs) are chemical substances and when applied in small amounts, they bring rapid changes in the phenotypes of the plant and also influence the plant growth, right from seed germination to senescence either by enhancing or by stimulating the natural growth regulatory system. Plant growth substances are known to enhance the source-sink relationship and stimulate the translocation of photo-assimilates thereby helping in effective flower formation, fruit and seed development and ultimately enhance the productivity of crops. Plant growth regulators played an important role in secondary metabolism governed in plants (Bohm, 1980).

MATERIAL AND METHODS

The experiment was carried out at Medicinal and Aromatic Plant Research Station, Anand Agricultural University, Anand during *Kharif* 2013 and *Kharif* 2014, which is situated on 22°-35' north latitude and 72°-55' east longitude and has an elevation of 45 metres above the mean sea level. The climate of Anand in middle Gujarat region is semi-arid and tropical. Winter is mild cool and dry, while summer is quite hot and dry. The hot temperature commences by about mid-February to ends by about middle of June. An average annual temperature for this region ranges from 34.4 °C to 40.9 °C and hottest month observed in the month of May. Winter sets in the middle of October and continues till the middle of February. Monsoon is warm and moderately humid. It commences by the middle of June and ends by the middle of September. An average rainfall of the tract is about 864 to 870 mm. Monsoon in this area is often erratic and

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uncertain, both in respect of total rainfall and its distribution.

Kalmegh *var.* Anand Kalmegh -1 was selected for the research. The seed was sown on nursery beds on 29 June 2013 and 20 June 2014. The seedlings were transplanted on 14th and 5th August 2013 and 2014, respectively with 45 x 30 cm spacing. Irrigation and weeding were done whenever necessary. The experiment was laid out in Split Plot Design with three replications which consists of five treatments *viz.,* NAA @ 100 mg l^{-1}, NAA @ 200 mg l^{-1}, GA_3@ 50 mgl^{-1}, GA_3 @ 100 mg l^{-1}, control (without spray) were applied at 45 days after transplanting (DATP) as a foliar application.

The data were recorded on andrographolide content (%) of control and treated plants with whole plant (root, shoot, leaves, pods and flowers). The five plants were uprooted at 60, 90 and 120 DATP from border rows of each treatment in a three replication. Soil was completely removed from root part and plant samples were dried at room temperature under shade up to 10 days. The dry plants were cut into small pieces and mix under cyclone sample mill for getting fine power. Sample preparation for LC/MS was carried out according to method described by Song *et al.*, 2013 with major modification such as hot water and sonication treatment. The dried fine powder of *A. paniculata* (0.20 g, 40 meshe) were accurately weighted and extracted in 10 ml methanol for 60 mins. under sonication followed by 60 mins. of incubation in hot water bath at 60°C. Samples were filtered through a sterile syringe filters (Axiva) 0.22 ìm nylon membrane. Five microliter of above filtrates was diluted in 1 ml of 65% ACN: 35 % Water (Therefore, Dilution factor was set to 200). Sample were taken in MS grade 2 ml glass vial and stored at 40°C temperature till use. Andrographolide contents of the whole plant of dry powder was analysed with the help of LC-mass spectrometry instrument available at Department of Biotechnology, Anand Agricultural University, Anand, Gujarat. Liquid chromatography (LC/MS/MS) mass spectrometry method has been developed for detection and quantification (LOD & LOQ) of andrographolide from biological sample *i.e.* whole plant dry basis in *Andrographis paniculata*. A QTRAP 4500 ion trap mass spectrometer (ABSCIEX) was connected to the Ekspert ultra LC 100 (Eksigent) instrument via an ESI interface. Turbo 'V' source were optimized based on compounds response in Total Ion Chromatogram (TIC) for parental mass detection (Fig.1 and 2). Presence of Andrographolide was confirmed in negative mode of ionization with centroid mass of 349.1 MW [M-H] in Q1MS scan mode that revealed compound losing one electron. In this study acetonitrile, methanol, water and 0.1% formic acid have found to be a good solvent system for efficient separation of andrographolide. ACQUITY UPLC-BEH C18 (2.1 X 50 mm, 1.7ìm) (Water Company) column was found suitable for used separating bioactive compound andrographolide from the constituents of *A. paniculata*. Validation parameters including calibration curves, linearity ranges, Limit of Detection (LODs), and Limit of Quantification(LOQs) was carried out using Analyst 1.6.1 software comes with instrument based on signal to noise ratio (S/N)with standard deviation (Shende *et al.* 2016). The statistical analysis of the data generated during the course of investigation was carried out through software following the procedure described by Walter and Freedom 2007 at Department of Agricultural Statistics, BACA, AAU, Anand.

RESULTS AND DISCUSSION

In the present study, significant differences were observed among the treatments of plant growth regulator with respect to biomass yield (g $plant^{-1}$ and kg $plot^{-1}$) during both the years as well as in pooled analysis (Table 1). Though, significantly higher dry biomass yield was noted in the treatment of NAA @ 200 mg l^{-1} (112.39 g $plant^{-1}$ and 5.37 kg $plot^{-1}$) compared to rest of treatments of plant growth regulator in pooled analysis at harvest. Results are in accordance with observation reported by Singh and Misra (2001) in *Mentha spicta*.

The plants sprayed with growth regulators remained physiologically more active to build up sufficient food reserve (source) for developing flowers and seeds (sink). The improvement in the yield and quality of the crops mainly depends on the concentration of plant growth regulator and time of application (Singh, 1995).

The results pertaining to the andrographolide per cent content of kalmegh as influenced by treatments of plant growth regulator showed significant differences during both the years and in pooled analysis (Table 2). Significantly higher andrographolide per cent content recorded in the treatment of NAA @ 200 mg l^{-1} (0.67, 2.31 and 1.04%) in pooled analysis at 60, 90 and 120 DATP. Pargi *et al.* (2014) reported that NAA application proved beneficial for quality of tomato. Similar

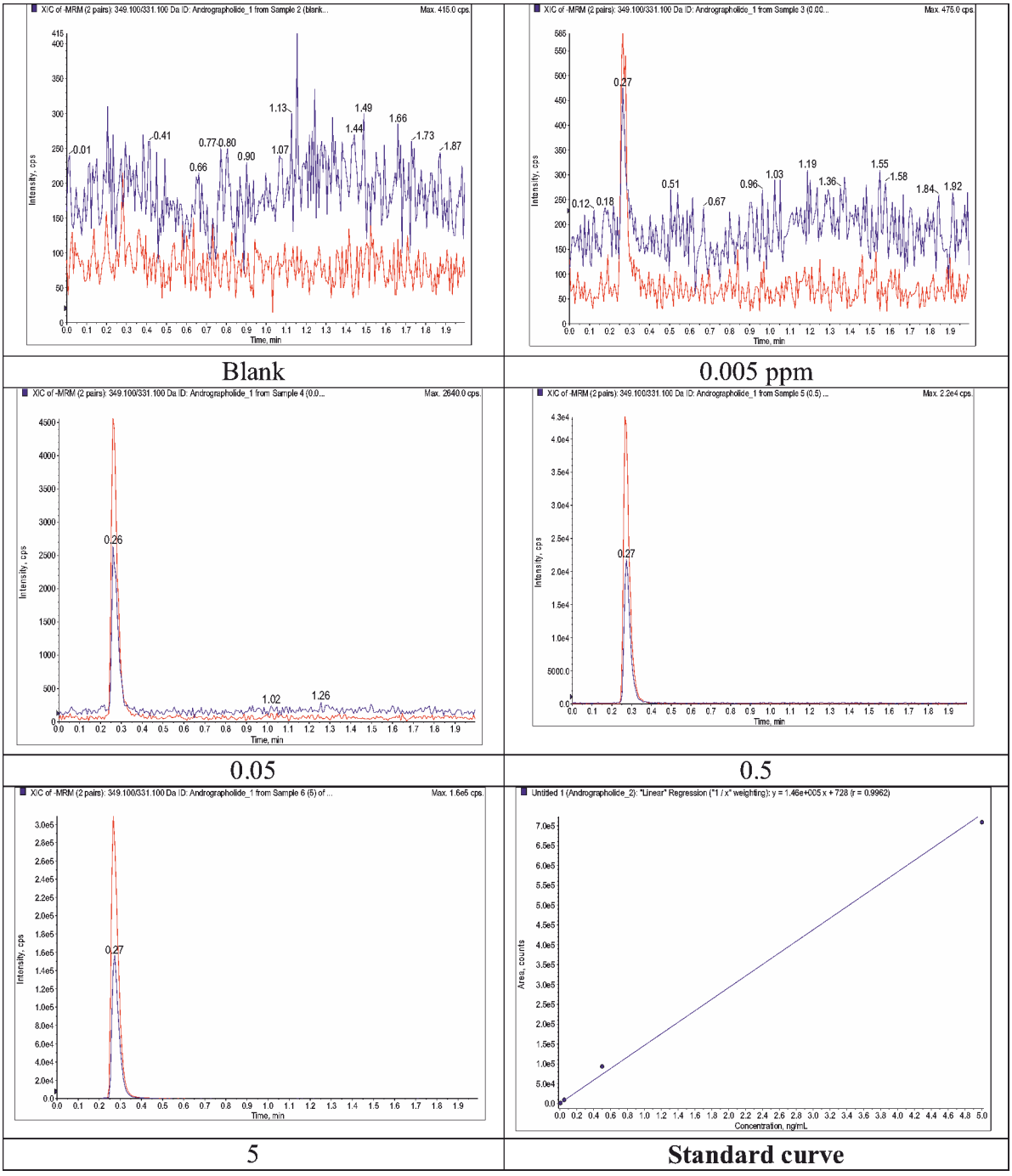

Fig. 1 : Standard peak of andrographolide compound with representation of qualifier and quantifier

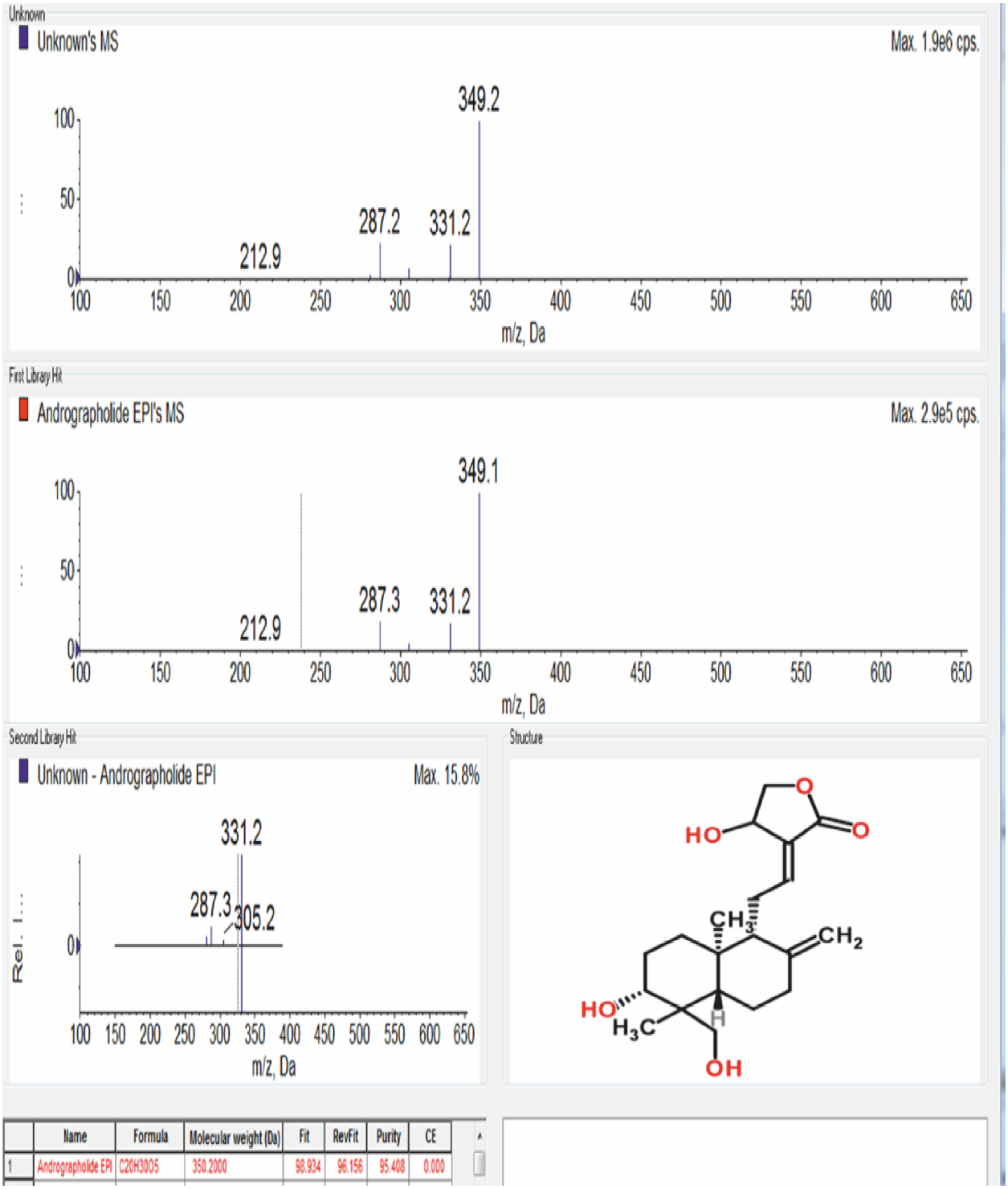

Figure 2 : Confirmation of andrographolide using library search based on Multiple Reaction Monitoring to Enhance Product Ion scan

Table 1 : Influence of plant growth regulator treatments on biomass yield of kalmegh

Treatments(PGR's spray)	Biomass yield (g plant^{-1})			Biomass yield kg plot^{-1}		
	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
S_1 :NAA @ 100 mg l^{-1}	102.83	107.25	105.04	4.94	5.15	5.04
S_2 :NAA @ 200 mg l^{-1}	110.14	114.64	112.39	5.29	5.44	5.37
S_3 :GA_3 @ 50 mg l^{-1}	93.40	97.00	95.20	4.48	4.66	4.57
S_4 :GA_3 @ 100 mg l^{-1}	96.69	99.65	98.17	4.64	4.78	4.71
S_5 :Control (water spray)	84.28	85.68	84.98	4.05	4.18	4.11
SEm±	1.62	2.93	1.67	0.18	0.14	0.12
CD (P=0.05)	5.27	9.56	5.01	0.60	0.47	0.35
CV %	6.42	11.26	9.25	15.20	11.60	13.46

Table 2 : Influence of plant growth regulator treatments on quality parameters of kalmegh (60, 90 and 120 DATP)

Treatments (PGR's spray)	Andrographolide content (%)		
	2013-14	2014-15	Pooled
60 DATP			
S_1 :NAA @ 100 mg l^{-1}	0.62	0.65	0.63
S_2 :NAA @ 200 mg l^{-1}	0.65	0.69	0.67
S_3 :GA_3 @ 50 mg l^{-1}	0.56	0.59	0.57
S_4 :GA_3 @ 100 mg l^{-1}	0.57	0.60	0.59
S_5 :Control (water spray)	0.41	0.44	0.43
SEm±	0.00	0.00	0.00
CD (P=0.05)	0.00	0.01	0.01
CV %	0.66	2.94	2.18
90 DATP			
S_1 :NAA @ 100 mg l^{-1}	2.23	2.28	2.25
S_2 :NAA @ 200 mg l^{-1}	2.28	2.33	2.31
S_3 :GA_3 @ 50 mg l^{-1}	1.89	1.94	1.91
S_4 :GA_3 @ 100 mg l^{-1}	1.91	1.95	1.93
S_5 :Control (water spray)	1.48	1.61	1.54
SEm±	0.01	0.01	0.02
CD (P=0.05)	0.02	0.04	0.07
CV %	1.10	2.13	1.70
120 DATP			
S_1 :NAA @ 100 mg l^{-1}	0.99	1.04	1.01
S_2 :NAA @ 200 mg l^{-1}	1.01	1.07	1.04
S_3 :GA_3 @ 50 mg l^{-1}	0.92	0.97	0.95
S_4 :GA_3 @ 100 mg l^{-1}	0.97	1.02	1.00
S_5 :Control (water spray)	0.76	0.80	0.78
SEm±	0.02	0.02	0.01
CD (P=0.05)	0.06	0.07	0.04
CV %	8.27	7.99	8.13

observation reported by Alwar and Subramanian (2013) showed increased in andrographolide content with the treatment of NAA at higher concentration.

Alwar and Subramanian (2013) reported the application of NAA and GA_3 helped to increase the andrographolide content. Kumar *et al.* (2012) reported that foliar application of PGR's showed significantly higher increase quality parameter than control in strawberry. Shitole and Dhumal (2011) indicated that PGR's application showed significant increase in yield attributes and sennoside content over the control in *C. angustifolia*. Anuradha *et al.* (2010) reported that the growth regulators treated plant showed increased in contents of andrographolide as compared to control. Gudhate *et al.* (2009) reported that, the application of NAA was very effective to enhance the andrographolide content over control in kalmegh.

CONCLUSION

The overall results have confirmed that PGRs treatments are effective for improving the dry biomass as well as andrographolide content in *Andrographis paniculata*. The final objective of sellers and buyers of medicinal plants is to get sufficient quantity of active secondary metabolites in them. Not only this, efficacy and efficiency of medicinal plants for therapeutic use is mostly depending on the same. From the results of present investigation on this aspect, it was found that NAA at the higher concentration of 200 mg l^{-1} is useful to improve the content of andrographolide .

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G x E Interaction and Phenotypic Stability for Yield and its Components in Wheat (*T. aestivum* L. and *T.durum* Desf.)

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ABSTRACT

In present investigation 16 wheat genotypes comprised of eleven bread wheat (*Triticum aestivum* L.) and five durum wheat (*Triticum durum Desf.*) were examined for stability at 3 locations and the data generated from the trials was analyzed using Eberhart and Russell Model(1966). Niphad location was proved to be the best environment as compared to Parbhani and Akola environments since, Niphad location produced significantly higher grain yield than Parbhani and Akola. The results revealed that the genotypic differences pooled over three environments were significant for yield and yield contributing characters. The mean sum of squares due to Environment and (G × E) interactions were highly significant for all the characters under study except spikelets spike^{-1}, The source of environment alone was highly significant all the characters, The G × E interaction mean sum of squares were highly significant for test weight, grain yield and straw yield. The environment linear component was highly significant for all the character depicting the presence of variability and chances of good selections for above mentioned traits under the environments. Genotype NIDW-0950 was found to be the most stable genotype across the environments for grain yield, test weight, effective tillers plant^{-1}, tillers sq.m^{-1} and spiklets spike^{-1} characters.

It is of vital importance to select high yielding genotypes along with stable performance across the environments. Obtaining high yields from wheat cultivation depends on the development and release of cultivars suitable for particular ecological conditions. Phenotype is an output of genotype (G), environment (E) and their interaction G x E (Eberhart and Russell, 1966). The basic cause of differences between genotypes in their yield stability is the wide occurrence of Genotype× Environment (GE) interactions, i.e. the ranking of genotypes depends on the particular environmental conditions where they are being grown (Becker and Leon, 1988). Therefore, GE interactions are the primary factors that concern plant breeders in the development new cultivars. The presence of a G x E interaction for seed yield as a quantitative trait can decrease the usefulness of subsequent analysis, restrict the significance of inference and seriously limits the feasibility of selecting favorable genotypes (Sabaghnia *et al.* 2013). Selection of stable genotype, which performs consistently across the environments, can reduce the magnitude of G x E interaction. The grain yield is output of genotype, environment and genotype x environment interaction (GEI). The GEI studies provide a basis for selection of genotypes that are suitable for general or specific ecology. They also provide information about the effect of environment on genotype performance (Khan *et.al.,* 2007)

MATERIAL AND METHODS

The present investigation was carried out during *rabi*, 2014-2015. In all sixteen genotypes, were evaluated at three locations with common sowing date of 13th November, 2015. The details are as under.

1. Wheat Research Unit of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. Geographical situation is 20.42°N latitude and 77.02°E longitude and 307.4 m above mean sea level. The average annual rainfall was 564 mm and the maximum temperature during crop growth was (29.1 to 41.6 ^{0}C) while minimum temperature was(10.8 to 24.1 ^{0}C)
2. Agricultural Research station, Mahatma Phule Krishi Vidyapeeth, Niphad Dist. Nashik. Geographical situation is latitude 20.07°N and 74.10°E longitude and 569 m above sea level. The average annual rainfall was 552 mm and the maximum temperature during crop growth was (24.9 to 38.0 ^{0}C) while minimum temperature was(5.5 to 20.2 ^{0}C)
3. Wheat Research Unit, Vasantrao Naik Marathwada Krishi Vidhyapeeth, Parbhani. Geographical situation is at 19.08°N latitude and 76.5°E longitude and 347 m above sea level. The average annual rainfall was 555 mm and the maximum temperature during crop growth was (27.5 to 40.0 ^{0}C) while minimum temperature was(6.3 to 22.9 ^{0}C)

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The genotypes comprised of eleven bread wheat (*Triticum aestivum* L.) and five durum wheat (*Triticum durum Desf.*). The experiment was carried out in the Randomized Complete Block Design with three replications in plot size of 14.40 sq.m. with 12 rows and 20 cm row spacing. All recommended agronomical package of practices were followed to raise the healthy crop. Investigation was based on the observations viz., effective tillers plant^{-1}, effective Tillers (sq. m^{-1}), Spiklets spike^{-1}, Spike length (cm), Grains spike^{-1}, Test weight (g) and Grain yield (kg plot $^{-1}$)

RESULTS AND DISCUSSION

The results of Analysis of Variance (ANOVA) presented in Table 1 revealed that the genotypic differences pooled over three environments were significant for yield and yield contributing characters indicating the presence of sufficient amount of variability for those characters and there is scope for selection of genotypes having desirable characters. Mean sum of squares due to Environment and (G × E) interactions were highly significant for all the characters under study except effective tillersplant^{-1} and spikelets spike^{-1} revealed that the environments and their interaction with genotypes played an important role in determining these traits. Similar results were reported by Singh and Pathania (2008) and Mondal *et al.* (2010). The variation due to environment alone was highly significant all the characters indicating the presence of variation in the environments selected for present study. The G × E interaction mean sum of squares were highly significant for test weight and grain yield for rest of the characters, the differences were non-significant. Similar results were reported by Yadav and Sharma (2008) and Yadav *et al.* (2009)

The environment linear component alone was highly significant for all the characters depicting the presence of variability and chances of good selections for above mentioned traits under environments selected for study (Kamal Tripura *et al.*, 2011). While, the G × E interaction linear source was highly significant for test weight, grain yield (kg plot^{-1}) and significant for grains spike^{-1} depicting the differential responses of genotypes for these traits in three environments. Present findings are in agreement with the results reported by Parveen *et al.* (2010) and Sabaghania *et al.* (2013).

Estimates of mean performance studied for seven characters are presented in Table 2. The differences in environmental index and range value for all the characters viz., effective tillers plant^{-1}, effective Tillers (sq. m^{-1}), Spiklets spike^{-1}, Spike length (cm), Grains spike^{-1}, Test weight (g) and Grain yield (kg plot $^{-1}$) was high. All three locations differed in respect of climatic conditions as it can be realized on the basis of latitude, longitude, rainfall and temperature. Niphad location was proved to be the best environment as compared to Parbhani and Akola environments since, higher grain yield levels are observed at this location as compared to Parbhani and Akola location.

In present investigation on the basis of grain yield (kg plot^{-1}) (Table 3) only genotype NIDW-0950 exhibited most stable performance, since it exhibited better grain yield (2.74 kg) as compared to the mean of population over the environments (3.21 kg) along with regression co-efficient value close to unity (0.926) and minimum deviation from regression (S^2di=0.034), thereby indicating its highly stable performance for grain yield over the environments. High yielding genotype NIDW-0950 also exhibited above average stability for the trait tillers plant^{-1} indicating that it may perform well in different environments for this character also, followed by the genotype AKAW 4739. Since it exhibited good grain yield (3.906 kg plot^{-1}) with regression co-efficient (1.656) and minimum deviation from regression (S^2di =0.002). Such kind of performance for various yield contributing characters by the stable genotypes was also reported by Yadav *et al.* (2009) and Parveen *et al.* (2010)

For individual yield contributing characters viz., effective tillers plant^{-1}, genotypes PBN 4876, NIAW 301, AKAW 4798 and NIDW 0950 were found stable as compared to other genotypes. Similarly, for number of tillers sq.m.$^{-1}$ genotypes AKAW 4739, AKAW 3722, PBN 4881 were found stable. For the number of spikelets spike^{-1} PBN 4881, PBND 5175, PBND 4825 were found stable, while for spike length, AKAW 4800, NIAW 2595 and NIAW 2539 were found most stable. For the character number of grains spike^{-1} genotype, NIAW 2595 was most stable while for test weight, the genotypes NIDW 0950, NIAW 2539 were the most promising genotypes.

According Tyagi *et al.* (2016), promising genotypes identified for different environments could serve as donors to develop multi-parent advanced generation integrated cross populations to stack genes/ alleles.

Table 1: Analysis of Variance for stability analysis

Sources	DF	Effective tillers plant^{-1}	Tillers sq. m^{-1}	Spikelets spike^{-1}	Spike length (cm)	Grains spike $^{-1}$	Test weight (g)	Grain yield kg Plot $^{-1}$
		1	2	3	4	5	6	7
Rep within Env.	6	0.04	41.65	0.06	0.02	2.66	0.64	0.00
Genotypes	15	0.62**	2440.73 **	6.55**	6.92 **	49.94 *	27.48 **	0.35 **
Env.+ (GX E)	32	0.14	249.59 **	0.29	0.66 **	99.21 **	6.01 **	0.75 **
Environments	2	0.94 **	3235.64 **	1.23 *	10.03 **	1039.84 **	9.95 **	6.90 **
GX E	30	0.08	50.52	0.23	0.04	36.50	5.75 **	0.35 **
Environments (Lin.)	1	1.88**	6471.28 **	2.46 **	20.07**	2079.68**	19.91 **	13.80**
GX E.(Lin.)	15	0.03	36.20	0.18	0.04	51.31 *	10.21 **	0.68 **
Pooled Error	90	0.04	97.59	0.20	0.02	3.91	0.58	0.02
Pooled Deviation	16	0.13 **	60.78	0.27	0.03	20.33 **	1.21 *	0.01
Total	**47**	**0.29**	**948.89**	**2.29**	**2.66**	**83.48**	**12.87**	**0.63**

*Significant at 5% probability level, **Significant at 1% probability level

Table 2: Mean, range and environment index estimated for yield and its contributing traits in wheat

S.N.	Character	NIPHAD			PARBHANI			AKOLA		
		Mean	Range	EI	Mean	Range	EI	Mean	Range	EI
1	Effective tillers plant^{-1}	3.70	2.30-5.30	0.278	3.26	2.66-4.27	-0.163	3.31	2.70-4.70	-0.115
2	Tillers sq. m.$^{-1}$	366.48	303.33-407.33	15.340	348.54	288-381	-2.597	338.40	307.33-377.33	-12.743
3	Spikelets spike^{-1}	15.31	12.33-18.33	0.319	14.81	12.33-16.67	-0.181	14.85	13-19	-0.139
4	Spike length (cm)	8.63	6.29-10.73	0.905	7.38	5.11-9.34	-0.342	7.16	5.02-9.14	-0.564
5	Grains spike^{-1}	54.06	36.45-74.22	8.750	43.69	27-60	-1.625	38.19	31.33-46	-7.125
6	Test weigh (g)	42.87	36.89-48.28	0.881	41.75	35.05-49.33	-0.239	41.35	30-51	-0.642
7	Grain yield kg plot^{-1}	3.97	3.10-5.16	0.758	2.84	2.07-3.72	-0.368	2.82	1.96-4.05	-0.390

Table 3: Stability parameters estimated for wheat genotypes

S.N.	Genotypes	Effective tillers plant^{-1}			Tillers sq.m.$^{-1}$			Spikelets spike^{-1}		
		Mean	bi	s²di	Mean	bi	s²di	Mean	bi	s²di
1	AKAW-4739	3.200	1.839	-0.019	323.889	0.996	-85.945	16.556	0.692*	-0.187
2	AKAW-4798	3.516	0.939	-0.041	369.111	0.754	-89.002	13.000	1.083	-0.146
3	AKAW-4800	3.400	0.755	0.041	331.889	0.859	-89.870	16.556	2.556	0.214
4	PBN-4876	4.578	1.207	-0.012	382.889	1.141	-83.767	15.889	0.301	-0.127
5	PBN-4881	3.467	1.338	-0.036	373.333	1.059	-70.516	16.667	0.992	-0.117
6	NIAW-2495	2.844	0.428	-0.040	299.000	0.778	585.627**	14.111	0.602	0.053
7	NIAW-2539	3.267	0.226	0.168*	308.778	0.859	-93.147	16.111	1.865	0.240
8	NIAW-2595	2.889	0.466	-0.008	358.222	1.687	44.509	14.778	1.684	-0.106
9	AKAW-3722	3.758	1.473	-0.038	374.556	1.055	-94.045	13.222	-0.782	0.015
10	MACS-6478	3.579	0.718	0.077	367.667	0.493	-79.760	15.000	1.895	0.815*
11	NIAW-301	3.689	0.913	0.044	380.778	1.599	-45.404	14.889	1.474	-0.003
12	AKDW-4525	2.979	0.715	-0.038	333.000	1.169	-80.577	12.667	-0.902	0.354
13	PBND-4825	2.979	1.901*	-0.041	368.889	0.903	-84.153	13.667	1.083	-0.146
14	PBND-5175	3.379	0.546	0.049	309.333	0.865	-92.283	15.333	0.902	0.354
15	NIDW-0950	3.200	1.160	0.071	365.889	0.891	-91.722	13.889	1.383	-0.186
16	NIDW-295	4.042	1.377	1.173**	371.000	0.893	-83.041	17.556	2.556	0.214
	Population Mean	**3.423**			**351.139**			**14.993**		

Table 3 contd.: Stability parameters estimated for wheat genotypes

S.N.	Genotypes	Spike length (cm)			Grains spike^{-1}			Test weight (g)			Grain yield kg plot^{-1}		
		Mean	bi	s^2di	Mean	bi	s^2di	Mean	Mean	Mean	Mean	bi	s^2di
1	AKAW-4739	8.262	1.257	0.061	54.297	2.210	0.668	38.984	5.664	1.978*	3.906	1.656	-0.002
2	AKAW-4798	7.172	1.315	-0.014	36.482	0.215	43.553**	42.306	3.682	-0.377	2.922	0.233**	-0.015
3	AKAW-4800	9.508	1.017	0.038	50.444	-0.034	75.650**	39.726	-3.093	-0.298	3.264	0.040**	-0.015
4	PBN-4876	9.611	0.821*	-0.023	45.444	1.353	50.243**	38.404	6.076	5.245**	2.968	2.380*	-0.014
5	PBN-4881	8.551	0.655	0.107*	48.260	0.781	2.304	37.226	-0.050	-0.520	3.201	1.699*	-0.013
6	NIAW-2495	8.900	0.992	0.133*	42.074	0.146	5.861	41.231	0.258	-0.086	3.292	-0.166**	-0.015
7	NIAW-2539	8.972	1.012	-0.018	43.704	0.800	21.813*	42.161	1.390	-0.498	3.647	0.389**	-0.015
8	NIAW-2595	9.012	1.184	-0.014	44.592	1.058	3.165	48.406	0.148	0.919	3.444	1.506*	-0.015
9	AKAW-3722	7.060	1.034	-0.021	44.074	1.474	0.526	39.887	-0.612*	-0.573	3.197	1.928	0.001
10	MACS-6478	9.220	0.768	-0.012	44.037	1.152	32.349**	43.762	-4.276	4.346**	3.747	-0.294	0.019
11	NIAW-301	8.177	1.057	-0.019	44.556	0.720	-0.860	42.501	1.913	-0.253	3.222	-0.073*	-0.012
12	AKDW-4525	5.651	1.069	-0.023	43.002	1.050	25.719**	42.667	2.673	0.494	2.681	0.571**	-0.015
13	PBND-4825	5.541	1.042	-0.012	44.926	1.529	-3.349	45.143	1.519	-0.479	3.107	1.799*	-0.014
14	PBND-5175	5.607	1.035**	-0.023	41.962	1.246	9.509	46.411	-2.666	0.707	3.047	1.582*	-0.014
15	NIDW-0950	5.594	0.784*	-0.023	49.148	1.896	-2.074	39.580	1.250	-0.371	2.739	0.926	0.034
16	NIDW-295	6.716	0.957	-0.022	48.000	0.404	-1.039	43.493	2.124	-0.226	2.982	1.824	-0.011
	Population Mean	**7.722**			**45.313**			**41.993**			**3.210**		

CONCLUSION

Thus any generalization regarding stability of genotypes for all the characters is too difficult since the genotype may not simultaneously exhibit uniform response and stability for all the characters. However, it was concluded that the genotype NIDW-0950 can be included in the hybridization program to converge the stability for grain yield and development of stable cultivar adapted to a wide range of environments.

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Productivity, Profitability and Soil Fertility as Influenced by Diversified Soybean Based Cropping Systems in Vidarbha Region of Maharashtra

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ABSTRACT

A field experiment was conducted at AICRP on Integrated Farming Systems Research field, Dr. P.D.K.V, Akola during 2005-06 to 2011-12 with an object to identify the most productive and profitable diversified soybean based cropping system under irrigated condition for *Vidarbha* region of Maharashtra. The experiment was laid out in RBD with four replications and ten diversified soybean based cropping systems in comparison to sorghum and pigeonpea under two and three tier crop sequence. Six years pooled results, revealed that the soybean seed equivalent yield (72.24 q ha^{-1}), gross monetary returns (Rs.1,44,970 ha^{-1}), net monetary returns (Rs.1,13,259 ha^{-1}), B:C ratio (4.53) with productivity (19.79 kg $ha^{-1}day^{-1}$) and profitability (Rs.310 $ha^{-1}day^{-1}$) were observed significantly higher in soybean-coriander-wheat followed by soybean – isabgul – *summer* groundnut crop sequence. Hence, these soybean – coriander - wheat and soybean – isabgul - summer groundnut crop sequences were found most remunerative in respect of productivity and monetary returns. Whereas, among tested various crop sequences soil fertility status (299, 22 and 361 NPK kg ha^{-1}) and net gain of (49, 9 and 80 kg NPK ha^{-1}) were recorded highest in soybean - chickpea crop sequence.

Soybean is most popular *kharif* crop in rainfed *Vidarbha* as it require less production cost, short duration and affordable oilseed crop, add lot of leaf litter and considering risk covering to some extent. Farmers follow sole or intercropping of soybean with long duration crops of cotton or pigeonpea. After harvest of soybean, intercrop cotton / pigeonpea crops kept as such in field to get additional benefits and vacated land is generally used for growing second crops of wheat, gram, mustard in *rabi*. In comparison to traditional two tier system and to check the possibility of three tier cropping system, various short duration crops having different growing values were tried in soybean based system in which land, time and season is utilized for growing spices crop like coriander for a month period as catch and cash crop before sowing of wheat and medicinal crop like isabgul. Soybeans are looked upon not merely as a means to supply food for humans and animals, but also improves the soil fertility through fixation of atmospheric nitrogen. It has capacity to fix 49-450 kg atmospheric N ha^{-1} (Wani *et al.* 1995) and adds about 1 tonne ha^{-1} leaf litter to soil thus enhances organic carbon and soil health *per se* (Vyas *et al.* 2008). Soybean – wheat cropping system with nutrient management practice recorded the highest total productivity followed by soybean- chickpea cropping system with integrated practice and also gave higher gross and net monetary returns for the whole cropping system period (Gallani *et. al.* 2013). Field experiment conducted at Pune in Maharashtra revealed that soybean equivalent yield (SEY) and system net returns (SNR) were significantly higher in soybean – wheat cropping system than soybean chickpea system (Jaybhay *et. al.* 2015). Soybean yields were more sustainable when grown before wheat rather than chickpea in rotation (Billore et. al. 2013). Soybean is generally followed by wheat in *rabi* season. Hence, to find out the possibility of growing other crops than wheat in *rabi* and *summer* season, this attempt has been made to study the performance of different crops under intensive cropping system after soybean in comparison with cereal-cereal and pulses-oilseed cropping sequences.

MATERIAL AND METHODS

A field experiment was conducted at AICRP on Integrated Farming Systems Research Farm, Dr.P.D.K.V, Akola during 2005-06 to 2010-11 with an object to identify most productive and profitable soybean based cropping system for *Vidarbha* region of Maharashtra. The experiment was laid out in RBD with four replications and ten soybean based cropping systems with comparison to sorghum and pigeonpea under two and three tier crop sequence *Viz.,*

T_1 - Sorghum-Wheat, T_2 – Soybean - Chickpea, T_3 – Soybean - Mustard, T_4 – Soybean - Safflower, T_5 – Soybean - Sorghum - Summer Groundnut, T_6 - Soybean-

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Mustard-Summer Groundnut, T_7 – Soybean – Isabgul - Summer Groundnut, T_8- Soybean-Coriander - Wheat, T_9 – Soybean + Pigeonpea (1:1) - Wheat and T_{10}- Pigeonpea-Chickpea + Mustard (1:1).

The soil of experimental site was clayey in texture having initial nutrient content value of 250, 13 and 281 NPK kg ha^{-1}. The system productivity and economic analysis were computed considering market price prevailed during individual year. Productivity and profitability of cropping systems were worked out on actual cropping duration in terms of soybean equivalent yield and net monetary returns (Devasenapathy *et al.* 2008). Statistical analysis of the data was done by using standard analysis of variance (Panse and Sukhatme, 1978).

RESULTS AND DISCUSSION

Kharif, rabi and summer cropping system production

Total production of soybean based cropping system differed significantly due to various cropping sequences. Based on six years experimentation, pooled mean showed significantly highest grain and straw yield (34.02 and 102.28 q ha^{-1}) in sorghum - wheat crop sequence. It may probably on account of higher yield of succeeding crop (Ramchandra *et. al.* 2007). While lowest grain yield (15.25 q ha^{-1}) was observed in pigeonpea – chickpea + mustard (1:1) and lowest straw yield in soybean – mustard – summer groundnut crop sequence. During *rabi* season, the highest yield of coriander (79.92 q ha^{-1}) and wheat (21.0 q ha^{-1}) were noticed in soybean- coriander-wheat crop sequence which was nearly followed by soybean- sorghum – summer groundnut crop sequence. In *summer*, the highest grain and straw yield was noticed in soybean – mustard- summer groundnut crop sequence (Table 1). Similar lines of work were also reported by Prajapat *et. al*, (2015) in soybean – wheat– mungbean system and soybean–wheat–fallow system.

Soybean seed equivalent yield

Perusal of the data presented (Table 2) revealed that significantly highest soybean seed equivalent yield (72.24 q ha^{-1}) was recorded with soybean - coriander - wheat system followed by soybean – isabgul - summer groundnut (70.69 q ha^{-1}) crop sequence. However, these treatments recorded significantly more soybean seed equivalent yield than rest of the sequence combinations. It might be due to higher yield potential, price of the produce, efficient utilization of space and time and use of short duration crops in sequence (Choudhary *et. al.* 2000). Whereas, crop sequence of soybean-chickpea, soybean-mustard, soybean – safflower and soybean + pigeonpea – wheat were found at par with each other and showed more

Table 1: Pooled Mean grain and straw yields of various systems as influenced by different soybean based crop sequences (Pooled Mean of 6 years)

Cropping System	Pooled Mean Yield (q ha^{-1})					
	Kharif		Rabi		Summer	
	Grain	Straw	Grain	Straw	Grain	Straw
T1 - Sorghum-Wheat	**34.02**	**102.28**	19.43	44.09	—	—
T2 - Soybean-Chickpea	17.84	38.66	16.82	31.97	—	—
T3 - Soybean-Mustard	20.91	38.54	17.78	31.64	—	—
T4 - Soybean-Safflower	20.27	38.10	17.62	20.49	—	—
T5 - Soybean-Sorghum-*summer* groudnut	21.23	38.70	**20.87**	**70.21**	17.39	26.51
T6 - Soybean-Mustard-*summer* groudnut	21.82	37.94	17.21	38.07	**19.94**	**28.14**
T7 - Soybean-Isabgul-*summer* groudnut	21.21	39.68	13.02	33.00	16.56	26.35
T8 - Soybean-Coriander- Wheat	20.89	39.70	**79.92**	30.72	—	—
	21.00	54.42				
T9 - Soybean + Pigeonpea(1:1)- Wheat	13.95	24.10	16.21	47.84	—	—
	10.52	32.40				
T10 - Pigeonpea- Chickpea + Mustard(1:1)	15.25	64.94	5.88	15.12	—	—
			2.89	15.68		

or less equal values for yields. Lowest soybean equivalent yield was noticed in sorghum-wheat. It might be because of continuation of cereal -cereal based crop sequence which had adverse effect on crop productivity and depletes nutrient status of the soil even though the production was higher in individual mean but the market price of these commodities was less comparatively during particular years.

Monetary returns

Significantly superior gross monetary returns (Rs.144970 ha^{-1}), net monetary return (Rs. 113259 ha^{-1}) and B:C ratio (4.53) were recorded by soybean - coriander – wheat crop sequence nearly followed by soybean - isabgul- summer groundnut, soybean – mustard- summer groundnut and soybean – sorghum – summer groundnut crop sequences. It might be because of inclusion of vegetables or spice crop of coriander, medicinal crop of isabgul and oilseed crop of groundnut in crop sequences which had given higher market values to the soybean based system. Whereas, lowest GMR and NMR were recorded with sorghum – wheat crop sequence. It might be due to cereal- cereal crop sequence which had less market value (Kumar and Yadav, 1995).

Productivity and profitability of cropping system

It measured in terms of yield day^{-1} and Rs day^{-1}dependent on total grain, produced value of system and period in days taken by crop to produce the yield (Ramchandra *et. al.* 2007). Productivity and profitability of cropping systems on actual cropping duration under soybean equivalent yield and net monetary returns were noticed higher (19.79 kg $ha^{-1}day^{-1}$and 310 Rs. $ha^{-1}day^{-1}$) with soybean - coriander – wheat followed by soybean – isabgul - summer groundnut (19.37 kg $ha^{-1}day^{-1}$and 270 Rs $ha^{-1}day^{-1}$). It might be due to higher yield of succeeding crop and their market values (Raju and Reddy, 2000).

Soil Fertility status

Based on 4 years pooled mean, significantly highest NPK content of soil was noticed in soybean - chickpea crop sequence (299, 22 and 361 NPK kg ha^{-1}) respectively. Almost all the treatments showed increased NPK content after 6 years cropping cycle due to inclusion of legume crops in sequence. Because legume crops have capability to fix atmospheric nitrogen and also adds leaf litter to the soil which may help to increase nutrients and improves health of soil. Similar line of work was carried

Table 2 : Soybean equivalent yield, monetary returns, crop productivity and profitability as influenced by soybean based crop sequences (Pooled mean of 6 years)

Crop Sequence	Soybean equivalent yield (q ha^{-1})	GMR (Rs ha^{-1})	NMR (Rs ha^{-1})	B : C Ratio	Crop Productivity (kg ha^{-1} day^{-1})	Crop Profitability (Rs. ha^{-1} day^{-1})
T1 - Sorghum-Wheat	25.50	64598	41448	2.78	6.99	114
T2 - Soybean-Chickpea	40.43	81893	59519	3.63	11.08	163
T3 - Soybean-Mustard	39.16	76475	57960	4.06	10.73	159
T4 - Soybean-Safflower	38.30	75269	56146	3.91	10.49	154
T5 - Soybean-Sorghum-*summer* groudnut	52.64	118801	80912	3.12	14.42	222
T6 - Soybean-Mustard-*summer* groudnut	64.93	129190	92659	3.52	17.79	254
T7 - Soybean-Isabgul-*summer* groudnut	70.69	136674	98449	3.57	19.37	270
T8 - Soybean-Coriander-Wheat	**72.24**	**144970**	**113259**	**4.53**	**19.79**	**310**
T9 - Soybean + Pigeonpea (1:1)- Wheat	40.05	90490	67385	3.88	10.97	185
T10 - Pigeonpea- Chickpea + Mustard(1:1)	30.63	69307	49077	3.38	8.39	134
SE±	1.21	2603	2597	—	—	—
CD 5%	3.51	7547	7531	—	—	—

Selling price (Rs q^{-1}) : *Sorghum grain Rs.900, Sorghum kadbi Rs.150, Wheat grain Rs.1250, wheat straw Rs.100, Chickpea grain Rs. 2100, Chickpea straw Rs. 100, Isabgul Rs.4000, Soybean Rs 2150, Mustard Rs. 2150, Safflower Rs. 1900, Rabi sorghum Rs 1500, Summer groundnut Rs. 2400, Coriander Rs.1000, Pigeonpea Rs. 3500.*

out and reported by (Wani *et. al.* 1995). Whereas, the sorghum – wheat crop sequence recorded reduction in N and P content and slightly increase in K content. Similarly soybean - coriander – wheat crop sequence reduced P content and slightly increase in N and K content. It might be due to synergetic effect of one nutrient on other (Table 3).

Net gain / loss in NPK

Among the various crop sequences (Table 3), soybean-chickpea recorded numerically higher NPK gain (49, 9 and 80 kg ha^{-1}) in soil after 6 year crop cycle followed by pigeonpea – chickpea + mustard (36 N, 6 P and 65 K kg ha^{-1}), while K gain of 67 kg ha^{-1} was recorded with soybean – sorghum – summer groundnut crop sequence. Whereas, negative values of NPK were observed in sorghum – wheat crop sequence. It might be because of adverse effect of cereal-cereal crop sequence on soil condition indicating less application of nutrients than required, ultimately showed negative balance of nutrients (Kumar and Yadav, 1995).

CONCLUSION

Soybean seed equivalent yield, gross monetary returns, net monetary return and B : C ratio were observed significantly higher in soybean-coriander-wheat crop sequence. Whereas, the NPK content in soil was noticed maximum in soybean-chickpea crop sequence. Considering the multiple advantages that can occur from soybean based cropping system particularly in the view of sustainable agricultural production and the environmental problems with current farming system. Hence, for getting higher monetary returns, soybean-coriander-wheat crop sequence proved to be most productive, profitable (remunerative) and soil fertility improvement with soybean – chickpea crop sequence was found under irrigated condition of *Vidarbha* region of Maharashtra.

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Table 3: NPK availability in soil and net gain / loss status at the end of 2010-11 as influenced by various crop sequences (Pooled mean of 4 years)

Tr.	Initial Status of Soil			Soil Status at the end (kg/ha)			Net gain (+) /Net loss (-) (kg ha^{-1})		
	2005-06			2007-08 to 2010-11			(4 yrs.)		
	N	P	K	N	P	K	N	P	K
T1	250	13	281	248	11	296	-2	-2	15
T2	250	13	281	**299**	**22**	**361**	**49**	**9**	**80**
T3	250	13	281	285	18	346	35	5	65
T4	250	13	281	285	18	337	35	5	56
T5	250	13	281	268	18	348	18	5	67
T6	250	13	281	279	17	330	29	4	49
T7	250	13	281	272	18	341	22	5	60
T8	250	13	281	261	12	324	11	-1	43
T9	250	13	281	279	14	335	29	1	54
T10	250	13	281	286	19	346	36	6	65
SE ±	-	-	-	4.09	1.49	10.62	-	-	-
CD 5%	-	-	-	11.88	4.32	30.81	-	-	-

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Effect of Different Irrigation Level on Growth Attributes of Potato Genotypes

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ABSTRACT

An agronomic investigation entitled "Response of potato genotype to different irrigation levels for Vidarbha region" was carried out during *Rabi* season of 2014-15 at the Agronomy Department, farm.The experiment was conducted with two genotypes of potato i.e. Kufri Pukhraj and Kufri Jyoti and four levels of irrigations scheduled on the basis of IW/CPE ratio which were 0.75 IW/CPE, 1.0 IW/CPE, 1.2 IW/CPE and 1.5 IW/CPE involving 8 treatment combinations.The experiment was laid out in Factorial Randomized Block Design with three replications. The gross and net plot size were 4.5 × 3.9 m^2 and 3.6 × 3.3 m^2, respectively. Buffer strips of 2 m between replications and 1 m between plots were kept to check the seepage effect. During this investigation was found that among the genotypes KufriPukhraj was found significantly superior than genotypeKufriJyoti in respect of growth parametersof potato.Viz,highest plant height (40.56), number of functional leaves (34.23), leaf area index $plant^{-1}$(0.907), dry matter accumulation (48.88) etc. Irrigation treatments significantly increased growth attributes.Treatments 1.5 IW/CPE ratio recorded maximum value of all the growth characters viz., plant height (43. 38), number of functional leaves (36.92), leaf area $plant^{-1}$ (0.949) and dry matter accumulation $plant^{-1}$(51.05) followed by treatments 1.2 IW/CPE ratios, 1.0 IW/CPE ratio and 0.75 IW/CPE ratio.

Potato (*Solanumtuberosum* L.) belonging to the family Solanaceae is the most important food crop of the world. (Herklots, 1972). Potato, an important temperate crop, has been adopted well for cultivation under sub-tropical conditions. The potato is a crop which always been the 'poor man's friend'. For vegetable purpose it has become one of the most popular crop in the country. Potatoes are an economical food; they provide a source of low cost energy to the human diet. Potatoes are rich source of starch, vitamins, especially C and B_1 and minerals. They contain 20.6 per cent carbohydrates, 2.1 per cent protein, 0.3 per cent fat, 1 per cent crude fibre and 0.9 per cent ash. They also contain a good amount of essential amino acid like leucine, tryptophane and isoleucine etc.

The non-adaption of improved agro techniques in a climate change scenario as potential genotypes, irrigation scheduling are the limiting factors for low productivity. The appropriate approach, irrigation base on critical growth stages of plant and irrigation based on soil moisture deficit have been intensively used for irrigation scheduling. Recently, the evaporative demand gained importance as the main factor in determining the water requirement of crop. The climatic parameters play an overriding role in governing the water needs of crop.

Therefore, to overcome the non-adaption agro techniques and present need of the area the effect of irrigation scheduling in changing climate situation needs to be evaluated. But the low cost approach for moisture conservation may contribute for increasing the potato production. With this background in view, the present investigation has undertaken to know the response of potato genotypes under different irrigation level in Vidarbha region.

MATERIAL AND METHODS

The field experiment "Response of Potato genotype to different irrigation levels for Vidarbha region" was conducted at Farm of Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during *Rabi* season of 2014-2015. The topography of the field was fairly uniform and leveled.The result of chemical analysis indicates that the experimental soil was clayey in texture, and low in available nitrogen,i.e.174.3(kg ha^{-1}), medium in available phosphate i.e 14.40 (kg ha^{-1}) and high in available potash i.e 371.33(kg ha^{-1}) and slightly alkaline in reaction having pH 7.8. The quantity of Organic Carbon in soil was 0.43 (g kg^{-1}). Electrical conductivity 0.240 (dSm^{-1}) and Bulk density (Mg m^{-3}) was 1.32.

RESULTS AND DISCUSSION

GROWTH PARAMETERS

Effect of Genotype

Data pertaining in table 1.is revealed that the plant height to various treatments of Genotype at all the

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stages of crop growth is significantly influenced in genotype Kufri Pukhraj (V_1) than Kufri Jyoti (V_2). Maximum plant height was recorded for Kufri Pukhraj (V_1) at all growth peridsand found significantly superior over Kufri Jyoti (V_2). The marked difference in the mean plant height might be due to the different genetic set up of the varieties used in the trial. The results obtained are in conformity with the findings of Amanullah *et al.* (2010).

Effect of irrigation levels

Data pertaining in Table 1 revealed that the plant height was significantly influenced due to the scheduling of irrigation at all the stages of crop growth. Among the different irrigation scheduling, irrigation scheduling at 1.5 IW/CPE (I_4) recorded significantly maximum plant height (43.38) at all the stages of crop growth than scheduling at 1.2 IW/CPE (I_3), 1.0 IW/CPE (I_2) and 0.75 IW/CPE (I_1). This may be attributed to better soil moisture status due to Irrigation at narrower interval, which might have resulted in better cell division and cell elongation. The above results are found agreed with the findings of Patel and Patel (2001).

Interaction effect

Interaction effect between Genotype and irrigation was found to be non significant in respect of plant height at all the crop growth stages.

Number of functional leaves plant^{-1}

The Data pertaining in Table 1 revealed thatthenumber of functional leaves as significantly influenced by different treatments at all the crop growth stages. The numbers of functional leaves plant^{-1} increased upto 75 DAP and thereafter, numbers of functional leaves again reduced towards maturity of the crop.

Effect of genotype

Data pertaining in Table 1.revealed that the genotype Kufri Pukhraj (V_1) produced significantly maximum number of functional leaves than genotype Kufri Jyoti (V_2) at all the crop growth stages. At 30 DAS, maximum number of functional leaves plant^{-1} (25.15) observed for Genotype Kufri Pukhraj (V_1) and found significantly superior over Genotype Kufri Jyoti (V_2).

Effect of irrigation levels

Among the different irrigation levels, irrigation scheduling at 1.5 IW/CPE (I_4) recorded significantly higher number of functional leaves than 1.2 IW/CPE (I_3), 1.0 IW/CPW (I_2) and 0.75 IW/CPE (I_1) . At 30 DAP,

Table 1. Plant height and Number of functional leaves plant^{-1} as influenced by different treatments.

Treatment	Plant height (cm)N					umber of functional leavesplant^{-1}				
	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS
Genotypes										
V_1 – KufriPukhraj	18.82	32.83	37.16	40.43	40.56	25.15	33.24	37.18	40.18	34.23
V_2 – KufriJyoti	17.92	31.53	35.48	38.18	38.26	24.62	32.13	36.10	38.47	33.32
SE (m) ±	0.25	0.31	0.40	0.46	0.48	0.11	0.24	0.28	0.34	0.30
CD at 5%	0.75	0.94	1.21	1.38	1.44	0.33	0.72	0.84	1.03	0.89
Irrigation levels										
I_1 – 0.75 IW/CPE	16.27	29.78	32.98	35.02	35.07	23.17	30.20	33.53	35.57	30.57
I_2 – 1.0 IW/CPE	17.90	31.97	35.72	38.55	38.68	24.13	32.00	35.87	38.03	32.83
I_3 – 1.2 IW/CPE	18.90	32.65	37.37	40.37	40.50	25.70	33.53	37.33	40.80	34.77
I_4 – 1.5 IW/CPE	20.40	34.30	39.22	43.27	43.38	**26.53**	35.02	39.83	42.90	36.92
SE (m) ±	0.35	0.44	0.57	0.65	0.67	0.15	0.34	0.39	0.48	0.42
CD at 5%	1.06	1.33	1.72	1.96	2.04	0.46	1.02	1.19	1.46	1.27
Interaction (V×I)										
SE (m) ±	0.49	0.62	0.80	0.91	0.95	0.22	0.48	0.56	0.68	0.59
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
GM	18.37	32.18	36.32	39.30	39.41	24.88	32.69	36.64	39.33	33.77

maximum number of functional leaves plant^{-1} (26.53) recorded with irrigation scheduling at 1.5 IW/CPE(I_4) which was found to be significantly superior over 1.2 IW/CPE (I_3), 1.0 IW/CPE (I_2) and 0.75 IW/CPE (I_1) at all the crop growth stages. This might be due to the number of functional leaves and leaf area are important indicator of total source available to plant for production of photosythates. The rate of incensement of number of functional leaves was increased rapidly up to 75 DAP and decreased thereafter due to leaf senescence till maturity. Similar results are reported by Netto *et al.* (1999).

Interaction effect

Interaction effect between Genotype and irrigation was found to be non significant in respect of number of functional leaves at all the crop growth stages.

Leaf area index (LAI)

Data pertaining in Table 2 revealed that leaf area index and dry matter progressively increases upto at 90 DAP.

Effect of Genotype

Data The Genotype Kufri Pukhraj (V_1) recorded significantly higher leaf area index at 75 DAP than Genotype Kufri Jyoti (V_2),The rate of increase in leaf area index at all growth stages except 90DAP was maximum. Maximum leaf area index was recorded for Kufri Pukhraj (V_1) (1.064) which was significantly superior over Kufri Jyoti (V_2) (1.033). at all stages of crop growth. The results are conformity with those recorded by Amanullah *et al.* (2010).

Effect of irrigation

Among the different irrigation levels, The irrigation scheduling at 1.5 IW/CPE (I_4) recorded significantly higher leaf area index (1.119) than irrigation scheduling at 1.2 IW/CPE (I_3), 1.0 IW/CPW (I_2) and 0.75 IW/CPE (I_1) at all stages of crop growth. At 30 DAP, maximum leaf area index (0.419) recorded with irrigation scheduling (I_4) at 1.5 IW/CPE which was found to be significantly superior over irrigation scheduling at 1.2 IW/CPE(I_3), 1.0 IW/CPE (I_2) and 0.75 IW/CPE (I_1). The leaf area index observed with Irrigation scheduling at 1.2 IW/CPE (I_3), 1.0 IW/CPE (I_2) and 0.75 IW/CPE (I_1) was at par to each other. At 45 DAP, maximum leaf area index (0.597) recorded with irrigation scheduling at 1.5 IW/CPE (I_4) which was found to be significantly superior over irrigation scheduling at 1.2 IW/CPE (I_3), 1.0 IW/CPE (I_2) and 0.75 IW/CPE (I_1).

Similar trend was found at 60 and 75 DAP. At 90 DAP, maximum leaf area index (0.949) recorded with irrigation scheduling at 1.5 IW/CPE (I_4) which was found to be significantly superior over irrigation scheduling at 1.2 IW/CPE (I_3), 1.0 IW/CPE (I_2) and at par with 0.75 IW/CPE (I_1). The results are conformity with those recorded by Patel *et al.* (2000) observed that leaf area index increased with increasing irrigation frequency.

Interaction effect

Interaction effect between Genotype and irrigation was found to be non significant in respect of leaf area index at all the crop growth stages.

Dry matter accumulation plant^{-1} (g)

Data pertaining in Table 2.revealed that total dry matter plant^{-1} as influenced by various treatment of Genotype and irrigation at all the crop growth stages.

Effect of Genotype

Among the two Genotype of Potato the Kufri Pukhraj (V_1) recorded significantly higher dry matter than Genotype Kufri Jyoti (V_2).At 30 DAP, with Kufri Pukhraj (V_1) Genotype observed maximum dry matter accumulation plant^{-1} (6.91 g). At 45, 60, 75 and 90 DAP total dry matter accumulation was recorded 20.78 g, 34.75 g, 45.88 g and 48.88 g respectively, which was significant over Genotype Kufri Jyoti (V_2).

This may be due to that the dry matter accumulation is a result of photosynthesis and the cumulative effects of all growth attributes namely stem weight, leaf weight and tuber weight. Genotype Kufri Pukhraj (V_1) have higher dry matter because Genotype Kufri Pukhraj (V_1) produced more number of branches, more number of functional leaves more tuber weight plant^{-1}. It was in conformity to research findings of Amanullah *et al.* (2010).

Effect of irrigation

Data presented in Table 2 in respect of mean dry matter accumulation plant^{-1} revealed significant difference in all the stages of crop growth. Among the different irrigation levels, irrigation scheduling at 1.5 IW/CPE(I_4) produced maximum dry matter plant^{-1} than 1.2 IW/CPE (I_3), 1.0 IW/CPE (I_2) and 0.75 IW/CPE (I_1) irrigation

Table 2. Leaf area index plant^{-1} and dry matter accumulation (g) as influenced by different treatments

Treatment	Leaf area index plant^{-1}					Dry Matter Accumulation (g)				
	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS
Genotypes										
V_1 – KufriPukhraj	0.37	0.54	0.919	1.064	0.907	0.370	0.545	0.919	1.064	0.907
V_2 – KufriJyoti	0.36	0.53	0.887	1.033	0.881	0.361	0.536	0.887	1.033	0.881
SE (m) ±	0.002	0.002	0.004	0.003	0.002	0.002	0.002	0.004	0.003	0.002
CD at 5%	0.006	0.006	0.012	0.009	0.008	0.006	0.006	0.012	0.009	0.008
Irrigation levels										
I_1 – 0.75 IW/CPE	0.307	0.474	0.832	0.960	0.822	0.307	0.474	0.832	0.960	0.822
I_2 – 1.0 IW/CPE	0.350	0.517	0.873	1.022	0.868	0.350	0.517	0.873	1.022	0.868
I_3 – 1.2 IW/CPE	0.385	0.574	0.939	1.092	0.937	0.385	0.574	0.939	1.092	0.937
I_4 – 1.5 IW/CPE	0.419	0.597	0.967	1.119	0.949	0.419	0.597	0.967	1.119	0.949
SE (m) ±	0.002	0.003	0.006	0.004	0.004	0.002	0.003	0.006	0.004	0.004
CD at 5%	0.008	0.009	0.018	0.014	0.012	0.008	0.009	0.018	0.014	0.012
Interaction (V×I)										
SE (m) ±	0.004	0.004	0.008	0.006	0.005	0.004	0.004	0.008	0.006	0.005
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
GM	0.365	0.540	0.903	1.048	0.894	0.365	0.540	0.903	1.048	0.894

scheduling. The lowest dry matter accumulation plant^{-1} was recorded with irrigation scheduling at 0.75 IW/CPE (I_1) at all the stages of crop growth. This may be due to that the dry matter accumulation plant^{-1} is the resultant of photosynthesis activity and photo morphogenesis and hence increase the irrigation frequency increasing dry matter accumulation (g) plant^{-1}. Irrigation scheduling at 1.5 IW/CPE (I_4) ratio, increase in number of leaves, leaf area and tuber weight plant^{-1} were the photosynthates produced and accumulated were at a higher rate and quantity through process of plant metabolism which ultimately replaced in dry matter production at higher rate. This result is in accordance with the findings of Netto *et al.* (1999), Gadysiak *et al.* (2001) and Patel and Patel (2000).

Interaction effect

Interaction effect between Genotype and irrigation was found to be non significant in respect of dry matter accumulation at all the crop growth stages.

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Response of Annual Chrysanthemum to Cycocel and Paclobutrazol for Growth, Flowering and Seed Yield

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ABSTRACT

An experiment was conducted at Horticulture Section, College of Agriculture, Nagpur during *rabi* season of year 2015-2016 on Annual chrysanthemum. The experiment was laid out in Randomized Block Design with nine treatments. The results of the experiment revealed that, plants of annual chrysanthemum sprayed with paclobutrazol 50 ppm recorded significantly minimum plant height (92.56 cm) followed by paclobutrazol 40 ppm and cycocel 2500 ppm. Significantly, maximum number of branches plant^{-1} (34.26), plant spread (46.76cm) and stem diameter (2.67cm) were recorded in plants sprayed with cycocel 2500 ppm. In respect of flowering parameters, early flower bud initiation (38.13 days), was reported in control. Whereas, significantly maximum number of flowers (106) were noticed when annual chrysanthemum plants sprayed with cycocel 2500 ppm. As regards yield contributing parameters, significantly seed yield ha^{-1} (11.33 q), test weight (2.40 g) and germination (89.32%) were increased when plants sprayed with cycocel 2500 ppm.

Annual chrysanthemum (*Chrysanthemum coronarium*) is a member of family Asteraceae. Annual chrysanthemum or crown daisy or garland chrysanthemum is a native of Southern Europe. It is a hardy annual flower crop resistance to disease pest attack with less cultural practices. Popularity of crop is increasing among the farmers for production of floral material for worship and garland, particularly in early summer months, when flowers inadequate in supply. Therefore, it is necessary to use a good quality seedsof annual chysanthemum for flower production. Natural upright growth habit of annual chrysanthemum produce less number of branches, minimum plant spread and less number of flowers which might be resulted in marginal profit to the farmer. In annual flower crops, flower yield is mainly dependent on number of flower bearing branches, which can be manipulated by arresting the vertical growth of plants and encouraging side shoots. The exogenous application of growth regulator stimulate flowering, pollination, fertilization, seed setting, better quality seed and seed yield (Sunitha, 2007) . The plant growth retardants such as cycocel and paclobutrazol are used to overcome the various factors that are responsible for low vegetative reproductive growth of crop and ultimately reduced down the economical yield in annual chrysanthemum and thereby increased monitory return to the farmers. Considering the above facts, present investigation was undertaken.

MATERIAL AND METHODS

The present investigation was carried out at Horticulture Section, College of Agriculture, Nagpur, during *rabi* season of the year 2015-2016 with nine treatments in Randomised Block Design. The treatments comprised of T_1– Control, T_2- Cycocel 1000 ppm, T_3- Cycocel 1500 ppm, T_4- Cycocel 2000 ppm, T_5- Cycocel 2500 ppm, T_6- Paclobutrazol 20 ppm T_7- Paclobutrazol 30 ppm T_8- Paclobutrazol 40 ppm and T_9- Paclobutrazol 50 ppm.

The annual chrysanthemum seeds were sown twenty five days before the actual transplanting date in the nursery on previously sterilized raised bed and seedlings were prepared. Seedlings were transplanted on raised bed with one seedling hill^{-1} in the experimental field on 15th October, 2015 at the distance of 60 cm x 45 cm. Recommended dose of farm yard manure and chemical fertilizers 5 tones FYM and 100:50:50 NPK kg ha^{-1}, respectively were applied. Common pinching was undertaken 15 days after transplanting. The solutions of cycocel (1000, 1500, 2000 and 2500 ppm) and paclobutrazol (20, 30, 40 and 50 ppm) were prepared as per treatment concentrations. The cycocel and paclobutrazol solutions of the respective concentration were sprayed once at 25 DAT. All plant protection measures were undertaken to protect crop from pest and diseases. Observations on plant height (cm), stem diameter

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(cm) and branches plant^{-1} were recorded at 90 DAT. Flowering parameters *viz.*, days to first flower bud initiation, days to 50 per cent flowering, flowers plant^{-1}. The yield contributing characters viz., number of seeds flower^{-1}, diameter of capitulum, weight of seeds plant^{-1}, yield of seeds ha^{-1}, test weight and germination percentage were recorded and analyzed statistically as per the method suggested by Panse and Sukhatme (1967).

RESULTS AND DISCUSSION

Growth parameters

Growth parameters were significantly influenced by different concentrations of growth retardants and presented in Table 1. The results revealed that, significantly the minimum plant height (92.56 cm) was recorded in treatment paclobutrazol 50 ppm. This might be due to the fact that an application of paclobutrazol at different concentrations may decrease the cell elongation and reduce plant height by minimizing the internodal length. The results are in conformity with the findings of Shivankar *et al.* (2014). The stem diameter of plants was significantly increased (2.67 cm) with application of cycocel 2500 ppm. Increase in stem diameter might be due to reduction in plant height and delayed lignifications with application of growth retardants. Similar results were obtained by Akbar *et al.* (2011) in dahlia. Korade (2012) and Shivankar (2010) also reported the facts that with application of cycocel these were increase in the diameter of stem. The number of branches plant^{-1} were recorded significantly maximum^{1} (34.26) in cycocel 2500 ppm followed by paclobutrazol 40 ppm (33.36). Increase in number of branches, might be due to the antagonizing action of retardants responsible for the apical dominance and thereby suppressed terminal bud growth, also decreased elongation of internodal length and as a result there was an increase in nodal count on main axis. So, accumulation of metabolites gets translocated towards auxiliary bud and these in turn resulted in stimulation in lateral branches.

Flowering parameters

Flowering parameters were significantly influenced due to application of different levels of growth retardants and presented in Table1. The control treatment recorded significantly early flower bud initiation (38.13) followed by cycocel 1000 ppm (42.26 days). As regards to the harvesting of seeds, significantly the minimum days (141 days) were required for harvesting of seeds from transplanting in control treatment followed by cycocel 1000 ppm (148 days). Whereas, significantly the maximum days required to seed harvesting were noticed in paclobutrazol 50 ppm (161 days). The flower bud initiation and days to harvesting from transplanting were delayed with an application of growth retardants. This might be due to the fact that, inhibition of endogenous synthesis of gibberllins in the plant could be responsible

Table 1. Growth and flowering of annual chrysanthemum as influenced by cycocel and paclobutrazol

Treatments	Plant height at 90 DAT (cm)	Stem diameter at 90 DAT(cm) transplanting	Branches plant^{-1} at 90 DAT (Days)	Days to first flower bud initiation after 90 DAT	Days for harvesting of seeds from transplanting	Number of flowers plant^{-1}at
T_1 - Control	116.44	2.20	25.20	**38.13**	141	82.06
T_2 - CCC 1000ppm	108.83	2.38	26.26	42.26	148	88.00
T_3 - CCC 1500ppm	104.18	2.48	29.26	44.16	152	94.03
T_4 - CCC 2000ppm	100.40	2.55	30.33	46.33	156	100.0
T_5 - CCC 2500ppm	**95.60**	**2.67**	**34.26**	50.23	158	**106.0**
T_6 - PCB 20ppm	101.08	2.51	26.20	43.13	147	90.02
T_7 - PCB 30ppm	96.36	2.58	28.40	45.53	149	96.01
T_8 - PCB 40ppm	95.35	2.61	33.26	49.30	155	102.0
T_9 - PCB 50ppm	**92.56**	2.66	30.26	53.66	161	93.33
SE (m) ±	3.38	0.07	1.04	1.54	2.82	3.36
CD at 5%	10.20	0.22	3.15	4.66	8.50	10.14

Table 2.Effect of cycocel and paclobutrazol on yield attributes of annual chrysanthemum

Treatments	Diameter of capitulum (cm)	Number of seeds flower^{-1}	Seed yield plant^{-1}(g)	Seed yield ha^{-1} (q)	Test weight (g)	Germination (%)
T_1- Control	1.73	182	26.20	5.57	1.80	76.33
T_2– CCC 1000 ppm	1.88	188	33.08	7.33	2.00	78.19
T_3- CCC 1500 ppm	1.90	194	40.48	8.94	2.22	82.18
T_4- CCC 2000 ppm	2.06	196	44.88	9.92	2.29	87.85
T_5- CCC 2500 ppm	2.23	202	51.38	11.33	2.40	89.32
T_6– PCB 20 ppm	1.85	186	31.50	6.88	1.90	78.48
T7-PCB 30 ppm	1.79	190	37.39	8.22	2.05	82.62
T_8– PCB 40 ppm	1.76	192	46.02	10.21	2.35	86.19
T_9- PCB 50 ppm	1.72	180	33.84	7.48	2.02	81.44
SE (m) ±	0.10	5.45	0.52	0.28	0.09	2.42
CD at 5%	0.31	16.36	1.59	0.86	0.28	7.28

for flower bud initiation. These finding are in line with the results obtained by Korde (2012), Shivankar (2010) and Navale *et al.* (2010) in chrysanthemum with application of cycocel. The number of flowers plant^{-1} was recorded significantly maximum (106) with the application of cycocel at 2500 ppm. Growth retardant cycocel reacted with gibberelic acid to lower down the level of diffusible auxin and thereby suppressing vegetative growth and production of more number of branches or auxiliary shoots with flowers located terminally. Similar finding were reported by Munikrishnappa and Chandrashekar (2014), with application of cycocel 2400 ppm in China Aster. Early flower initiation and early harvesting of seeds were noticed in control treatment compared to paclobutrazol. This might be due to the endogenous synthesis of gibberllins,which could be responsible for flower bud initiation. Whereas, growth retardant paclobutrazol 50 ppm reported maximum days for harvesting of seeds might be due to the blocking the process conversion of geranyl pyrophosphate to capalyl pyrophosphate which is first step to gibberelline synthesis which in turn inhibits endogenous synthesis of gibberllins, actually responsible for flower bud initiation in the annual chrysanthemum.

Yield parameters

The yield contributing parameters significantly influenced by application of different concentrations of growth retardants in annual chrysanthemum are presented in Table 2. The number of flowers plant^{-1} recorded significantly maximum (106.00) with spraying of cycocel 2500 ppm followed by paclobutrazol 40 ppm (102.00). The results are in conformity with the findings of Shivankar *et al.* (2014), who reported that 1000 ppm cycocel sprayed at 30 and 45 days after transplanting significantly increased number of flowers plant^{-1}. Increase in number of flowers plant^{-1} might be due to the reduction in plant height, increase lateral vegetative growth, stem diameter, number of branches and finally number of flower plant^{-1}. Similar results were also reported by Khan (2012) with spraying of cycocel 2000 ppm, Dorajeerao *et al.* (2012) with an application of cycocel 3000 ppm produced maximum number of flowers plant^{-1} in African marigold. Asgarian *et al.*(2013) also found with paclobutrazol 30 mg per litre spray with significantly increased flower numbers in Zinnia.

In respect of number of seeds flower^{-1}, significantly maximum (202) with application of cycocel 2500 ppm followed by the treatment comprises of cycocel 2000 ppm (196). Whereas, minimum numbers of seeds flower^{-1} were noticed in paclobutrazol 50 ppm (180). Significantly, the highest seed yield plant^{-1} was obtained under cycocel 2500 ppm (51.38 g) followed by paclobutrazol 40 ppm (46.02 g). It has been observed that significantly highest seed yield hectare^{-1} (11.33 q) was noticed under cycocel 2500 ppm. This clearly indicate that, the higher seed yield produced because of by foliar application of cycocel might be due to the maximum utilization of reserved food and increased mobilisation of biomass to seed from the source to sink which resulted higher seed weight. Increase seed yield ha^{-1} might be due

to more number of branches. The apical dominance of plant, suppressed and allowed lateral branches or auxiliary shoots with flowers resulting in to the more number of capitulum. The results are in close agreement with the findings of Darajeerao *et al.* (2012) with foliar application of cycocel 3000 ppm in Annual Chrysanthemum. Sainath *et al.* (2008) in annual chrysanthemum with foliar spray of cycocel @1000 ppm and @ 2000 ppm. Further, Singh (2004)also agrred with the present investigation with his study undertaken in African marigold with 10 mg paclobutrazol spray .

CONCLUSION

The results of the experiment revealed that, plants of annual chrysanthemum sprayed with paclobutrazol 50 ppm recorded significantly minimum plant height (92.56 cm) followed by paclobutrazol 40 ppm and cycocel 2500 ppm. Significantly, maximum number of branches plant^{-1} (34.26), and stem diameter (2.67cm) were recorded in plants sprayed with cycocel 2500 ppm. In respect of flowering parameters, early flower bud initiation (38.13 days), was reported in control treatment. Whereas, significantly the maximum number of flowers (106) were noticed when annual chrysanthemum plants sprayed with cycocel 2500 ppm. As regards to the yield contributing parameters, significantly the maximum seed yield ha^{-1} (11.33 q), test weight (2.40 g) and germination (89.32%) were observed when the annual chrysanthemum plants were sprayed with cycocel 2500 ppm.

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Efficacy of Pre and Post Emergence Herbicide on Growth and Yield of Garlic (*Allium sativum* L.)

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ABSTRACT

The experiment was conducted at Chilli and Vegetable Research Unit, Dr. PDKV., Akola, during *rabi* seasons of 2011-12, 2012-13 and 2013-14. The trial was undertaken on Broad Bed Furrow (BBF) with drip irrigation system in Randomized Block Design (RBD) with eight treatments, replicated thrice. The treatments comprising Oxyfluorfene @ 0.100 Kg. a.i. ha^{-1} as pre emergence followed by hand weeding at 40 DAS. (T_1), Pendimethaline @ 1.00 Kg. a.i. ha^{-1} as pre emergence followed by hand weeding at 40 DAS. (T_2), Oxyfluorfene @ 0.100 Kg. a.i. ha^{-1} as pre emergence followed by Quizalofop ethyl @ 0.050 kg. a.i. ha^{-1} at 30 DAS. (T_3), Pendimethaline @ 1.00 Kg. a.i. ha^{-1} as pre emergence followed by Quizalofop ethyl @ 0.050 kg. a.i. ha^{-1} at 30 DAS (T_4), Oxyfluorfene @ of 0.100 Kg. a.i. ha^{-1} as pre emergence followed by Fenoxaprop-p-ethyl @ 0.100 kg. a.i. ha^{-1} at 30 DAS (T_5), Hand weeding at 20, 40, 60 and at 80 DAS (T_6), Weed free treatment (T_7) and Weedy check (T_8).

The results indicated that, significantly the maximum yield of garlic bulbs (117.99 q/ha) was produced due to an application of treatment Weed free (T_7) and was found at par with the treatment Oxyfluorfene @ of 0.100 Kg. a.i. ha^{-1} as pre emergence followed by Fenoxaprop-p-ethyl @ 0.100 kg. a.i. ha^{-1} at 30 DAS (T_5).

The minimum weed dry matter, weed index and maximum weed control efficiency was noticed due to an application of treatment Oxyfluorfene @ of 0.100 Kg. a.i. ha^{-1} as pre emergence followed by Fenoxaprop-p-ethyl @ 0.100 kg. a.i. ha^{-1} at 30 DAS (T_5). The quality of garlic bulbs in respect of bulb diameter, bulb length and clove index was improved due to application of treatment T_7 which was statistically at par with treatment T_5.

Garlic belongs to the family Aliaceae. It is second most important bulb crop after onion. It has origin is central Asia (Rai and Yadav, 2006) and it is then spread to Mediterranean region. The bulb of garlic comprises a number of segments called clove, which range from 16 to 50 and are enclosed in the sheath of white and red color. In India, garlic is grown widely over 11.65 lakh ha. with 147.40 lakh tones production having 12.65 ton per ha of productivity. In India, Gujrat, Madhya Pradesh, Maharashtra, Uttar Pradesh, Karnataka, Bihar are the major garlic producing states. Uttar Pradesh and Maharashtra produces 28 per cent of garlic in the country. In Maharashtra state, total production of garlic is 0.60 lakh tones, form an area of 0.08 lakh ha. (Lawande and Prasad, 2007).

Weed infestation is one of the major problem, that the farmer is exposed in the course of crop production apart from the non-availability of better inputs. Garlic is a shallow rooted, narrowly spaced crop with slow initial growth and short stature. Therefore, it is incapable to compete with aggressive weeds and weeds may reduce the bulb yields to the extent of 40 to 60 per cent (Sandhu *et al.*, 1997). In India, hand weeding in garlic is common practice, but it is tedious, laborious, time consuming and expensive. Sometimes due to scarcity of labour at critical stage of crop growth, the yield levels may reduce drastically. Pre-emergence herbicides are effective for about a month period after its applications. Therefore, it is essential to screen the pre and post emergence herbicides for their effective doses under particular agro climatic conditions for effective control of weeds in garlic. Keeping the above factors in view, the present investigation was undertaken.

MATERIAL AND METHODS

The experiment was conducted at the field of Chilli and Vegetable Research Unit, Dr. PDKV., Akola during three consequent years i.e. from 2011-12, 2012-13 and 2013-14 in Randomized Block Design (RBD) with three replications. The experiment was undertaken on Broad Bed Furrow with drip irrigation system. The variety used for the experiment was G-41 (Agrifound white) and sown at the spacing of 15 X 10 cm. The treatment used with pre and post emergence herbicides along with hand weeding and comprising of, T_1- Oxyfluorfen @ 0.100 kg a.i.

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ha^{-1} followed by 1 HW at 40 DAS, T_2- Pendimethalin @ 1.00 kg a.i. ha^{-1} followed by 1 HW at 40 DAS, T_3 - Oxyfluorfen @ 0.100 kg a.i. ha^{-1} pre emergence followed by Quizalofop ethyl @ 0.050 kg a.i. ha^{-1} at 30 DAS, T_4- Pendimethalin @1.00 kg a.i. ha^{-1} pre emergence followed by Quizolofop ethyl @ 0.050 kg a.i. ha^{-1} at 30 DAS, T_5- Oxyfluorfen @ 0.100 kg a.i. ha^{-1} pre emergence followed by Fenoxaprop-p-ethyl @ 0.100 kg a.i. ha^{-1} at 30 DAS, T_6 - HW at 20,40,60 and 80 DAS, T_7- Weed free harvesting of the crop, T_8 – Weedy Check. The data collected from each year and that of pooled analysis was undertaken with the help of statistical methods described by Panse and Sukhatme(1978).

The weed floras observed in the experimental plot were differentiated into the monocot and dicot weeds. The monocot weeds were *Cyperus rotundus* L, *Cynodon dactylon*, *Commelina benghalensis* and *Dinebra retroflexa*. The dicot weeds were *Physalis minima*, *Chenopodium album* L, *Portulaca oleracea* L, *Tridax procumbens* L, *Laga scamollis*, *Parthenium hysterophorus*, *Euphorbia geniculata* Otleg., *Euphorbia hirta* L, *Phyllanthus niruri* L, *Amaranthus viridis* L and *Sida anlata*.

RESULTS AND DISCUSSION

The pooled data pertaining to the growth parameters, dry matter production, yield and quality of garlic as influenced by different weed management practices are presented in respective tables.

It is observed from the pooled data presented in the Table 1.1 that, weed free treatment (T_5) produced significantly the maximum (78.11 cm) plant height of garlic crop. Whereas, it was reported minimum (56.75 cm) in the weedy check (T_8) treatment. Similar trend of results were also noticed in individual years. This might be due to the reason that, the crop faced minimum weed competition and thereby able to get maximum light, air, moisture and nutrients. Similar results were reported by Patel *et al* (1986) in onion, Habid Urrahman *et al* (2011) in garlic.

Number of Leaves per plant differed, significantly among the treatments and the maximum (13.74) leaves were produced by the garlic plant getting (Oxyfluorfen @ 0.100 kg a.i. ha^{-1} pre emergence + Fenoxaprop-p-ethyl @ 0.100 kg a.i. ha^{-1} at 30 DAS) T_5 treatment. The treatment T_4, T_5 and T_7 were found statistically at par with each other. Whereas, the minimum (8.27) number of leaves per plant in garlic were produced by weedy check (T_8) treatment (Table 1.1). Application of pre and post emergence herbicide treatments, before and after emergence of weeds in the garlic plot reduced the population of weeds which resulted in the maximum utilization of light. Furthermore, the maximum metabolic activities were undertaken in such plants, due to which, there might be more accumulation of food material and ultimately resulted into the maximum number of leaves. These results are in line with the findings of Ramani and Khanpara 2010, in garlic.

Evaluation of the yield levels of any crop lies on superiority of weed management practice applied. Weed free plot of garlic crop (T_7) produced significantly the maximum (117.99 q ha^{-1}) cured yield of garlic bulb. But was found at par with the treatment (114.77 q ha^{-1}) T_5. However, lowest yield (68.39 q ha^{-1}) cured yield of garlic zulb was recorded in weedy check (T_8).

This might be due to the fact that, wherever there was better weed control and maintenance of higher plant population in bulbous crops like garlic, the competition in between the crop for light, air, moisture and nutrient would have reduced down considerably. The decrease in the competition would might be resulted into an increase in yield contributing characters like height and leaves per plant, diameter of bulb, cloves per bulb etc., and ultimately reflects into maximum cured bulb yield of garlic. Similar results were reported by Sharma *et al.* 1983 and Kolhe., 2001 in garlic.

As regards to weed dry matter recorded in Table 1.2, opined that, the minimum weed dry matter (43.96 g/m^2) was produced by the treatment T_5 and it was closely followed by the treatment T_6. However, the maximum weed dry matter (192.56 g/m^2) was recorded in the weedy check (T_8) treatment. An application of pre and post herbicides and hand weeding in garlic, decreased the number and weight of weed, which might be responsible for reduction in dry matter (g/m^2) of it accordingly. The similar results were quoted by Mohommad and Imran (2003) in garlic.

Effect of various herbicides and hand weeding treatments on weed control efficiency and weed index are presented in Table (1.2) and it is noticed that, the maximum (77.18) weed control efficiency was obtained in treatment T_5 and was closely followed (76.28) in the hand weeding treatment at 20, 40, 60 and at 80 DAS (T_6). The weed

Table 1.1 . Influence of pre and post emergence herbicides on weed count in garlic.

Treatments		Monocot weeds (m^2)				Dicot weeds (m^2)			
		2011-12	2012-13	2013-14	Pooled mean	2011-12	2012-13	2013-14	Pooled mean
T_1 -	Oxyfluorfen @ 0.10 kg a.i./ha + 1 HW at 40 DAS	27.91	25.18	25.93	26.34	18.66	16.34	16.86	17.29
		(5.28)	(5.02)	(5.09)	(5.13)	(4.32)	(4.04)	(4.11)	(4.16)
T_2 -	Pendimethalin @ 1.00 kg a.i./ha followed by 1 HW	29.36	25.74	27.50	27.53	19.74	15.41	14.33	16.49
	at 40 DAS	(5.42)	(5.07)	(5.24)	(5.25)	(4.44)	(3.93)	(3.79)	(4.06)
T_3 -	Oxyfluorfen @ 0.100 kg a.i./ha before planting	23.47	20.14	19.08	20.90	21.39	18.69	18.00	19.36
	followed by Quizalofop ethyl @ 0.050 kg a.i. /	(4.84)	(4.49)	(4.37)	(4.57)	(4.62)	(4.32)	(4.24)	(4.40)
	ha at 30 DAS								
T_4 -	Pendimethalin @1.00 kg a.i./ha before planting	19.37	17.64	17.26	18.09	13.47	11.29	13.95	12.90
	followed by Quizolofop ethyl @ 0.050 kg a.i./ ha	(4.40)	(4.20)	(4.15)	(4.25)	(3.67)	(3.36)	(3.73)	(3.59)
	at 30 DAS								
T_5 -	Oxyfluorfen @ 0.100 kg a.i./ha before planting	17.89	15.47	16.66	16.67	15.07	13.64	12.11	13.61
	followed by Fenoxaprop-p-ethyl @ 0.100 kg	(4.23)	(3.93)	(4.08)	(4.08)	(3.88)	(3.69)	(3.48)	(3.69)
	a.i./ha at 30 DAS								
T_6 -	HW at 20,40,60 and 80 DAS	24.56	22.54	16.33	21.14	22.67	19.85	14.00	18.84
		(4.96)	(4.75)	(4.04)	(4.60)	(4.76)	(4.46)	(3.74)	(4.34)
T_7 -	Weed free harvesting of the crop	—	—	—	—	—	—	—	—
T_8 –	Weedy Check	59.37	63.54	54.33	59.08	33.25	32.41	28.00	31.22
		(7.71)	(7.97)	(7.37)	(7.69)	(5.77)	(5.69)	(5.29)	(5.59)
	F test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
	SE(m)±	0.96	0.52	0.84	1.37	0.66	0.59	0.73	1.42
	CD at 5%	2.88	1.55	2.55	4.17	1.98	1.79	2.21	4.33

Figures in parenthesis indicates square root transformations

Table 1.2 . Influence of pre and post emergence herbicides on dry matter, CE and WI in garlic.

Treatments	Weed dry matter (g/m²)				Weed control efficiency (%)				Weed index (%)			
	2011-12	2012-13	2013-14	Pooled mean	2011-12	2012-13	2013-14	Pooled mean	2011-12	2012-13	2013-14	Pooled mean
T_1 - Oxyfluorfen @ 0.10 kg a.i./ha + 1 HW at 40 DAS	64.37	62.51	71.66	66.18	66.06	68.23	62.53	65.61	20.49	30.71	22.72	24.64
T_2 - Pendimethalin @ 1.00 kg a.i./ha + 1 HW at 40 DAS	66.94	61.25	66.33	64.84	64.70	68.87	65.32	66.30	16.10	30.23	18.56	21.63
T_3 - Oxyfluorfen @ 0.100 kg a.i./ha before planting + Quizalofop ethyl @ 0.050 kg a.i. / ha at 30 DAS	67.59	64.55	64.88	65.67	64.36	67.19	66.08	65.88	25.35	34.16	23.29	27.60
T_4 - Pendimethalin @1.00 kg a.i./ha before planting + Quizolofop ethyl @ 0.050 kg a.i./ ha at 30 DAS	63.24	59.87	61.11	61.41	66.65	69.57	68.05	68.09	4.55	10.86	5.11	6.84
T_5 - Oxyfluorfen @ 0.100 kg a.i./ha before planting + Fenoxaprop-p-ethyl @ 0.100 kg a.i./ha at 30 DAS	43.55	47.34	40.99	43.96	77.04	75.94	78.57	77.18	1.86	6.78	1.89	3.51
T_6 - HW at 20,40,60 and 80 DAS	46.91	45.37	44.66	45.65	75.26	76.94	76.65	76.28	12.78	30.23	18.93	20.65
T_7 - Weed free harvesting of the crop	—	—	—	—	100.00	100.00	100.00	100.00	—	—	—	—

Table 1.3 . Influence of pre and post emergence herbicides on growth and yield attributes in garlic

Treatments		Plant Height (cm)				Leaves per plant				Cured yield q/ha			
		2011 -12	2012 -13	2013 -14	Pooled mean	2011 -12	2012 -13	2013 -14	Pooled mean	2011 -12	2012 -13	2013 -14	Pooled mean
T_1 -	Oxyfluorfen@ 0.10 kg a.i./ha + 1 HW at 40 DAS	61.91	68.44	66.48	65.61	9.24	10.47	10.06	9.92	85.36	93.00	90.66	89.67
T_2 -	Pendimethalin@ 1.00 kg a.i./ha + 1 HW at 40 DAS	55.36	60.17	65.72	60.42	9.67	10.80	10.66	10.38	90.07	93.64	95.40	93.04
T_3 -	Oxyfluorfen @ 0.100 kg a.i./ha before planting + Quizalofop ethyl @ 0.050 kg a.i. / ha at 30 DAS	64.37	74.22	69.64	69.41	10.24	12.54	10.00	10.93	80.14	88.36	84.88	84.46
T_4 -	Pendimethalin @1.00 kg a.i./ha before planting + Quizolofop ethyl @ 0.050 kg a.i./ ha at 30 DAS	69.44	77.33	72.28	73.02	12.36	13.64	11.36	12.45	102.47	119.64	111.40	111.17
T_5 -	Oxyfluorfen @ 0.100 kg a.i./ha before planting + Fenoxaprop-p-ethyl @ 0.100 kg a.i./ha at 30 DAS	78.36	81.66	74.31	78.11	14.33	15.37	11.53	13.74	105.36	125.11	113.84	114.77
T_6 -	HW at 20,40,60 and 80 DAS	73.49	78.34	73.28	75.04	11.94	11.04	11.33	11.44	93.64	93.64	95.03	94.10
T_7 -	Weed free harvesting of the crop	77.00	80.01	74.73	77.25	13.46	14.34	11.76	13.19	107.36	129.21	117.40	117.99
T_8 –	Weedy Check	51.66	57.37	61.23	56.75	7.64	8.47	08.70	8.27	79.91	66.37	58.88	68.39
	F test	Sig.	Sig.	Sig	Sig.	Sig	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
	SE(m)+	2.45	0.67	1.30	0.88	0.66	0.71	0.56	0.81	0.69	0.59	0.78	1.07
	CD at 5%	7.37	2.01	3.95	2.67	1.97	2.14	1.71	2.47	2.09	1.79	2.37	3.23

Table 1.4 . Influence of pre and post emergence herbicides on qualitative attributesin garlic.

Treatments		Length of bulb (cm)				Diameter of bulb (cm)				Clove Index (g) (weight of 100 cloves)			
		2011 -12	2012 -13	2013 -14	Pooled mean	2011 -12	2012 -13	2013 -14	Pooled mean	2011 -12	2012 -13	2013 -14	Pooled mean
T_1	Oxyfluorfen @ 0.10 kg a.i./ha + 1 HW at 40 DAS	2.81	2.98	2.86	2.88	3.41	3.39	3.65	3.48	78.36	86.37	81.48	82.07
T_2	Pendimethalin @ 1.00 kg a.i./ha + 1 HW at 40 DAS	2.89	2.81	2.90	2.87	3.22	3.12	3.53	3.29	75.09	77.34	78.13	76.85
T_3	Oxyfluorfen @ 0.100 kg a.i./ha before planting + Quizalofop ethyl @ 0.050 kg a.i. / ha at 30 DAS	2.61	2.69	2.67	2.66	2.88	3.01	2.99	2.96	73.91	75.41	74.88	74.73
T_4	Pendimethalin @1.00 kg a.i./ha before planting + Quizolofop ethyl @ 0.050 kg a.i./ ha at 30 DAS	3.12	3.34	3.03	3.12	3.51	3.77	3.68	3.65	74.65	77.36	82.16	78.06
T_5	Oxyfluorfen @ 0.100 kg a.i./ha before planting + Fenoxaprop-p-ethyl @ 0.100 kg a.i./ha at 30 DAS	3.13	3.13	3.08	3.15	3.81	3.91	3.89	3.87	83.27	88.94	84.16	85.12
T_6	HW at 20,40,60 and 80 DAS	2.97	3.09	2.99	3.02	3.63	3.87	3.43	3.64	81.64	83.54	82.32	82.50
T_7	Weed free harvesting of the crop	3.18	3.18	3.10	3.16	3.91	3.94	3.92	3.92	85.34	91.34	85.90	87.53
T_8	Weedy Check	2.40	2.40	2.44	2.41	2.74	2.74	2.71	2.73	69.34	73.64	70.64	71.21
	F test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
	SE(m)+	0.076	0.13	0.70	0.67	0.07	0.04	0.57	0.65	0.68	0.79	0.56	0.84
	CD at 5%	0.231	0.39	2.14	2.06	0.22	0.13	1.74	1.97	2.09	2.38	1.71	2.56

Figures in parenthesis indicates square root transformations

index over the years of experimentation, and in pooled (3.51 %) weed index was obtained by the garlic crop due to an application of the T_5 treatment and was closely followed by T_4 treatment. This might be due to the satisfactory control of weeds and reduced the crop weed competition, which enabled the crop to utilize the available resources effectively and hence resulted in higher cured garlic bulb yield. Similar results were obtained by Warade *et at* (2008) in Onion.

Significantly the garlic bulbs with maximum diameter and length 3.92 cm, 3.16 cm, respectively were obtained by weed free harvestings of garlic crop (T_7) and it was found at par with weedicide treatment T_5 (3.87cm and 3.15 cm, respectively) and T_4 (3.65 cm and 3.12 cm, respectively). However, these were noticed to be minimum (2.73 cm and 2.41 cm, respectively) in weedy check treatment (T_8). However, significantly the maximum (87.53 g) clove index was recorded with the treatment (T_7) wherein, an application of weed free harvesting of the crop was undertaken throughout the life span of garlic crop. This might be due to the fact that, more the diameter and length of cloves, more would be the diameter and length of garlic bulbs. These results are in line with the findings of Mohommad and Imran (2003) in garlic.

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Effect of Mycorrhiza, Zinc and Molybdenum on Growth and Yield of Greengram

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ABSTRACT

A field experiment entitled "Effect of Mycorrhiza, Zinc and Molybdenum on Growth and Yield of Greengram" was carried out at Pulses Research Unit, Dr. PDKV, Akola during *Kharif* season of 2015-16 on clayey soil to study the effect of mycorrhiza, zinc and molybdenum on growth and yield of greengram. Yield attributes and grain yield were recorded significantly higher with RDF + Mycorrhiza (AM) @ 10 kg ha^{-1}+ Seed Soaking of 1 per cent $ZnSO_4$followed by RDF + Seed Soaking of 1per cent $ZnSO_4$.Gross monetary return, net monetary return and B:C ratio was recorded higher with application of RDF + AM @ 10 kg ha^{-1} + Seed Soaking of 1per cent $ZnSO_4$ closely followed by RDF + Seed Soaking of 1 per cent $ZnSO_4$.

Greengram (*Vigna radiata* L.) is third most important pulse crop of India after chickpea and pigeon pea. Besides being a major source of protein for human consumption and high quality crop residue for animal feed, it helps in maintaining the soil fertility through biological nitrogen fixation. Greengram fixes about 63-112 kg N ha^{-1} per season in soil by biological nitrogen fixation. Zinc deficiency is widespread in the country around 50 per cent of the soils are deficit (Dash *et al.* 2005). Increased use of high-analysis fertilizer and less or no use of organic manure and continuous multiple cropping with fertilizer-responsive varieties of crops have accentuated the depletion of their reserves in the soil, often leading to significant responses to their application. Zinc deficiency reduces not only the grain yield, but also the nutritional quality of grain and ultimately nutritional quality of human diet. As molybdenum is a constituent of nitrate reductase, deficiencies of molybdenum blocks nitrate assimilation resulting in nitrate accumulation. Deficiency of molybdenum, therefore, causes nitrogen deficiency symptoms in addition to molybdenum deficiency symptoms. Arbuscular Mycorrrhiza (AM) Fungi is an association or symbiosis between the roots of most land plants and many soil fungi that colonize the cortical tissue of roots during periods of active plant growth, from which both partners benefit. VAM enlarges root areas of host plants (10%) and improves its efficiency of water absorption, enhances the absorption of P and other nutritional elements and improves nutritional status of host plants.

MATERIAL AND METHODS

The field experiment was carried out at Pulses Research Unit in the plot No.31b of Sorghum Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *kharif* 2015. The fertility status of the soil was clayey in texture, slightly alkaline in nature, moderate in organic carbon, medium in available nitrogen (238 kg ha^{-1}), moderate in phosphorus (19.10 kg ha^{-1}) and moderately high in available potassium (382 kg ha^{-1}). The greengram cv PKV Greengold was sown on 19th June 2015 keeping 45 cm distance between two rows while plant to plant distance maintained was 10 cm and harvesting was under taken 3rd September 2015. Rainfall received during cropping season was 448.9 mm in 23 rainy days. The crop experienced dry spell of 21 days immediately after sowing during 26 to 28 MW resulted into stunted growth.The recommended dose of fertilizer (20 kg N and 40 kg P_2O_5 ha^{-1}) was applied through urea (46% N) and Diammonium phosphate (18:46 N: P_2O_5) at the time of sowing. Arbuscular Mycorrhiza soil application @ 10 kg ha^{-1}as per dose and seed soaking in 1per cent $ZnSO_4$ and 1per cent Ammonium Molybdate with its foliar spray at the time of flowering. The data collected were statistically analysed using analysis of variance technique and Least Significant Difference (LSD) test at 5 per cent probability to compare the difference among the treatments means.

RESULTS AND DISCUSSION

Grain yield of greengram was significantly influenced by soil applied mycorrhiza, seed soaking and foliar application of (1%) zinc and molybdenum. The data in Table 1 revealed that the highest seed yield (836 kg ha^{-1}) was observed with application of RDF + Rhizobium + Phosphorus Solublising Bacteria (PSB) + AM soil application @ 10 kg ha^{-1}+ seed soaking in 1per cent $ZnSO_4$ subsequently followed by RDF + seed soaking with zinc

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Table 1. Grain yield, ancillary parameters and economics of greengram as influenced by various treatments

Treatments	Grain yield (kg ha^{-1})	No. of pods plant^{-1}	Pod length (cm)	No. of seed pod^{-1}	Seed weight plant^{-1} (g)	Test weight grains (g)	Cost of cultivation (Rs ha^{-1})	Gross monetary returns returns (Rs ha^{-1})	Net monetary (Rs ha^{-1})	Benefit: Cost Ratio
T_1 - Absolute control	573	9.50	7.52	8.71	3.63	31.34	14050	31560	17510	2.25
T_2 - RDF + Rhiobium + PSB	659	10.73	7.67	8.75	3.95	31.74	15150	35916	20766	2.37
T_3 - T_2 + Mycorrhiza (AM) @ 10 kg ha^{-1}	680	10.81	7.69	8.79	3.99	31.91	15500	37308	21808	2.41
T_4 - T_2 + Seed soaking 1% $ZnSO_4$	790	12.02	8.10	9.06	4.29	32.29	15225	43080	27855	2.83
T_5 - T_2 + Seed soaking 1% Ammonium Molybdate	730	11.32	7.75	8.90	4.15	32.17	15390	40016	24626	2.60
T_6 - T_2 + Mycorrhiza @ 10 kg ha^{-1} + Seed soaking 1% $ZnSO_4$	836	12.90	8.12	9.18	4.41	32.47	15575	45478	29903	2.92
T_7 - T_2+ Mycorrhiza @10 kg ha^{-1} + Seed soaking 1% Ammonium Molybdate	754	11.60	7.77	8.92	4.17	32.22	15740	41256	25516	2.62
T_8 - T_2 + Mycorrhiza @ 10 kg ha^{-1} + Foliar Spray 1% $ZnSO_4$	710	11.27	7.74	8.85	4.13	32.16	17225	38920	21695	2.26
T_9 - T_2 + Mycorrhiza @ 10 kg ha^{-1} + Foliar Spray 1% Ammonium Molybdate	706	11.20	7.71	8.85	4.09	32.14	19975	38704	18729	1.94
SE (m) ±	9.01	0.37	0.10	0.07	0.06	0.09	-	463.91	463.91	-
CD at 5 %	27.00	1.12	0.30	0.20	0.18	0.28	-	1390.80	1390.80	-

sulphate (T_4) this indicated that soil application of mycorrhiza did not influenced the grain yield significantly as greengram being a short duration crop, effective infection of AM fungi could not be established within this period and perhaps their effect was not realized. The similar result was noted in greengram by Thamizh (2016). Similarly the grain yield recorded with application of RDF + seed soaking in 1per cent Ammonium Molybdatewas remained at parwith (T_7) or without mycorrhiza (T_5) and their foliar spray (T_9). The increased yield might be only due to positive effect of zinc on yield attributes viz., pods plant^{-1}, seeds pod^{-1}and seed weight plant^{-1} as it plays an important role in metabolic process. These primary yield components have been shown to be directly correlated with the yield (Khan 1985, Panwar *et al.*, 1986). Zinc enriched seeds perform better with respect to seed germination, seedling growth and yield of crops Rahman *et al.* (2015). Highest net monetary returns of Rs. 29903 were recorded with RDF + Rhizobium+ PSB + AM Soil Application @ 10 kg ha^{-1}+ Seed Soaking of $ZnSO_4$ @ 1per cent followed by RDF + PSB + Rhizobium + Seed Soaking of $ZnSO_4$ @ 1 per cent (Rs.27855). The lowest net monetary returns of Rs.17510 were recorded in control.

Zinc seed soaking was found to strengthen the possitive effect of bio fertilization. So, dual inoculation of greengram with Rhizobium, PSB and mycorrhiza accompanied with zinc seed soaking resulted in a considerable improvement of greengram growth, yield and yield components.

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Potassium Nutrition for Yield and Quality of Chickpea in Swell Shrink Soils

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ABSTRACT

Field experiment conducted for studying the response of potassium to high yielding chickpea variety SAKI-9516 in swell shrink soil revealed that 30 kg K_2O ha^{-1} significantly increased the yield of chickpea along with improvement in residual soil fertility, growth and yield contributing characters, physical grain quality as well as protein content. Application of two foliar sprays of potassium nitrate @ 2 per cent along with recommended N and P_2O_5 was also found beneficial for yield as compared to only N and P_2O_5 with no potassium. The nutrient use efficiency was improved due to application of potassium in conjunction with nitrogen and phosphorus ensuring balanced fertilization. The synergistic effect of potassium with nitrogen was also evident through improved nutrient uptake, yield and quality of chickpea. The results of present study revealed the necessity of application of potassium in optimum amount to high yielding crop cultivars in black swell shrink soils for improved nutrient use efficiency, yield and quality as well as also to avoid further mining of potassium in soils.

Among the major nutrients, potassium not only improves yields but also benefits various aspects of quality. Most crops absorb as much or more K than they absorb N from the soil. The nutrient removal exceeds nutrient addition. Potash balance in soils of Maharashtra is negative and mining of soil K reserves is going on at an alarming pace (Patil *et al.,* 2001). Usually soils having less than 120 kg ha^{-1} of Ammonium acetate extractable K are rated low in available K, between 120 and 280 kg ha^{-1} K medium and above 280 kg ha^{-1} as high in available K (Muhr *et al.,* 1965). These rating limits are irrespective of soils or crops. Gajbhiye *et al.,* (1993) attributed the lack of response below 200 mg kg^{-1} Ammonium acetate K in Vertisols to the state of soil hunger for K.

Chickpea is major pulse crop grown in Maharashtra on shallow and medium deep swell shrink soils in *rabi* season under intensive cultivation of double cropping. These soils experience continuous mining of nutrients. The introduction of high yielding fertilizer responsive crop cultivars grown under intensive conditions, depletion of soil nutrients, like potassium, is taking place at an alarming rate without sufficient replenishment. Considering the popularity and marketability of chickpea Dr. PDKV, Akola has developed a new high yielding cultivar of chickpea SAKI-9516. However, in the existing fertilizer recommendations before the present study, potassium was not recommended to chickpea. It is a general practice among farmers to apply nitrogen and phosphorus and by and large, no potassium is applied to chickpea. However, in view of decline in potassium status of soils and low productivity of chickpea, a field experiment was conducted for three years to study the response of chickpea to application of potassium in predominant swell shrink soils categorized as Inceptisols.

MATERIAL AND METHODS

The field experiment on chickpea high yielding variety SAKI-9516 was conducted for three years (2008-09 to 2010-11) at Research Farm, Pulses Research Unit, Dr. PDKV, Akola, Maharashtra. The study area represents semi arid climate and the soil moisture regime is ustic and soil temperature regime is hyperthermic. The experimental soil was clay loam in texture, medium deep, belonging to Typic Haplustepts, low in organic carbon (4.4 g kg^{-1}), available N (183 kg ha^{-1}) and P (13.5 kg ha^{-1}) and high in K (310 kg ha^{-1}). Eight different treatments in three replications were laid out in randomized block design. The treatments comprised of absolute control (T_1), Recommended Dose (RD) of fertilizers to chickpea (25: 50 kg N, P_2O_5 ha^{-1}) (T_2), four levels of potassium @ 20, 30, 40 and 50 kg K_2O ha^{-1} along with RD (T_3 to T_6), one foliar spray of two per cent KNO_3 at the onset of flowering with RD (T_7) and two foliar sprays of KNO_3, first at the onset of flowering and second after 15 days with RD (T_8). The nutrients viz. N, P_2O_5 and K_2O were applied to soil through urea, single super phosphate and muriate of potash.

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The seed treatment with trichoderma (4 g kg^{-1} seed), rhizobium (25 g kg^{-1} seed) and phosphorus solubilizing bacteria (20 g kg^{-1} seed) was given before sowing. Three irrigations were given and the gross plot size of 4.0 m x 3.6 m, net plot of 3.8 m x 3.0 m, with 30 x 10 cm spacing was used. Effect of potassium through soil and foliar application in combination with recommended nitrogen and phosphorus on growth, nutrient uptake, yield and quality of chickpea was studied.

RESULTS AND DISCUSSION

Growth and yield parameters

The data pertaining to growth and yield attributing parameters (Table 1) reveals that the highest plant height was recorded at 40 kg K_2O ha^{-1} and it was found at par with the remaining treatments except control. The pooled data showed that the number of branches, number of pods and nodules per plant showed significant increase at 30 kg K_2O ha^{-1} over the RDF.

Grain and straw yield of chickpea

The pooled data over three years revealed that application of 30 kg K_2O ha^{-1} along with recommended dose of N and P_2O_5 (T_4) recorded significant increase in grain yield of chickpea over lower levels of potassium (T_3) and only N and P_2O_5 (T_2) (Table 1). However, yield at 40 kg K_2O ha^{-1} was found at par with 30 kg K_2O ha^{-1} indicating response of chickpea to potassium up to 30 kg ha^{-1} (Table 1). The yield obtained at application of foliar sprays of potassium nitrate @ 2 per cent was found at par with the RDF.

Table 1. Grain and straw yield of chickpea with growth and yield attributes (Pooled data for 2008-09 to 2010-11)

Treatments	Plant Height (cm)	No of Branches $plant^{-1}$	Pods $plant^{-1}$	Yield (q ha^{-1})	
				Grain	Straw
T_1 - Absolute control	40.28	6.57	51.78	16.49	23.21
T_2-100 % RDF	42.51	7.02	61.53	20.30	30.04
T_3- RDF*+ 20 Kg K_2O	43.32	7.20	65.33	23.15	30.78
T_4- RDF+ 30 Kg K_2O	44.09	7.59	66.18	25.00	33.17
T_5- RDF+ 40 Kg K_2O	45.16	8.09	67.84	25.85	33.90
T_6- RDF+ 50 Kg K_2O	43.74	7.70	68.44	23.20	31.85
T_7- RDF+ 2% KNO_3 (Once)	44.61	7.30	65.42	20.69	29.93
T_8- RDF+ 2% KNO_3 (Twice)	44.38	7.64	64.57	22.21	33.22
CD (P = 0.05)	1.75	0.48	2.52	0.94	1.74

*RDF: Recommended dose of fertilizers to chickpea (25: 50 kg N, P_2O_5 ha^{-1})

Table 2. Nutrient uptake by chickpea (Pooled data for 2008-09 to 2010-11)

Treatments	Protein (%)	Uptake of nutrients (kg ha^{-1})		
		N	P	K
T_1 - Absolute control	16.49	67.28	11.48	22.22
T_2-100 % RDF	17.53	91.63	16.89	31.94
T_3- RDF*+ 20 Kg K_2O	17.85	102.64	19.82	34.15
T_4- RDF+ 30 Kg K_2O	18.37	114.38	22.35	37.42
T_5- RDF+ 40 Kg K_2O	18.81	118.32	22.98	39.06
T_6- RDF+ 50 Kg K_2O	18.75	108.30	20.39	35.80
T_7- RDF+ 2% KNO_3 (Once)	18.25	95.93	18.05	33.01
T_8- RDF+ 2% KNO_3 (Twice)	18.60	106.98	21.36	37.56
CD (P = 0.05)	0.29	4.14	0.69	1.76

Application of potassium at 30 kg K_2O ha^{-1} along with RDF recorded 23 per cent increase in yield of chickpea over only RDF. There was an increase of 15.6 kg grain kg^{-1} K indicating higher response to K applied at 30 kg K_2O ha^{-1} (Fig. 1). An average increase of 5, 14 and 7 kg grain kg^{-1} K applied to chickpea, pigeonpea and pea was reported in northern states of India (Ali and Srinivasa Rao, 2001). Higher response of pulse crops to potassium as compared to cereals and oil seeds has been reported by Tiwari and Nigam, (1985) and Srinivasa Rao *et al.,* (1999). It is further reported that cereals deplete more soil K whereas legumes depend more on applied K for their K needs. The results of present study also support this and reveal the necessity of applying potassium to swell shrink soils in spite of their high potassium status owing the significant response recorded to the applied potassium to chickpea.

Uptake of nutrients

Total uptake of nutrients was significantly increased with increasing levels of potassium up to 40 kg K_2O ha^{-1} (Table 2). The highest uptake of nitrogen, phosphorus and potassium was observed at 40 kg K_2O ha^{-1} which was at par with the uptake at two foliar sprays of potassium nitrate.

Grain quality

The protein content as well as test weight (Table 3) in chickpea grains was increased with the application of potassium in combination with recommended dose of N and P_2O_5. The significant increase in protein content was recorded up to 30 kg K_2O ha^{-1}. The physical quality of chickpea grains revealed that the length, breadth and thickness of chickpea grains (Table 3) were slightly

Table 3. Test weight, protein content and physical quality of chickpea ooled data for 2008-09 to 2010-11)

Treatments	Test weight(g)	Protein (%)	Physical quality		
			Length (cm)	Breadth (cm)	Thickness (cm)
T_1 - Absolute control	16.49	16.49	7.59	6.23	6.07
T_2-100 % RDF	17.53	17.53	8.17	6.31	6.18
T_3- RDF*+ 20 Kg K_2O	17.85	17.85	8.20	6.49	6.21
T_4- RDF+ 30 Kg K_2O	18.37	18.37	8.22	6.56	6.24
T_5- RDF+ 40 Kg K_2O	18.81	18.81	8.27	6.61	6.26
T_6- RDF+ 50 Kg K_2O	18.75	18.75	8.28	6.51	6.26
T_7- RDF+ 2% KNO_3 (Once)	18.25	18.25	8.17	6.47	6.18
T_8- RDF+ 2% KNO_3 (Twice)	18.60	18.60	8.19	6.50	6.22
CD (P = 0.05)	0.29	0.29	0.04	0.075	0.073

Table 4. Residual soil fertility status (After three years)

Treatment	Available nutrients (kg ha^{-1})		
	N	P	K
T_1 - Absolute control	178	12.73	330
T_2-100 % RDF	219	23.22	346
T_3- RDF*+ 20 Kg K_2O	230	24.23	350
T_4- RDF+ 30 Kg K_2O	237	25.22	364
T_5- RDF+ 40 Kg K_2O	245	27.73	386
T_6- RDF+ 50 Kg K_2O	244	27.32	398
T_7- RDF+ 2% KNO_3 (Once)	215	21.85	347
T_8- RDF+ 2% KNO_3 (Twice)	216	22.27	341
CD (P = 0.05)	5.94	1.58	12.39

increased with the increasing levels of potassium over the only use of nitrogen and phosphorus. The soil application of potassium was found superior to foliar spray in respect of size of chickpea grains. The shrinking of grains was observed to be less due to application of potassium as compared to only RDF.

Soil nutrient status

The residual fertility status of experimental soil after harvest of chickpea (Table 4) revealed that significantly higher nitrogen, phosphorus and potassium were observed due to application of potassium @ 40 kg K_2O ha^{-1} along with recommended N and P_2O_5 as compared with the use of only N and P_2O_5. The significant increase in available nitrogen status can be attributed to the effect of added K which has synergistic effect with N and also rhizobium inoculation which is beneficial in increasing the N fixation (Ali and Srinivasa Rao, 2001).

Nutrient use efficiency

The nutrient use efficiency calculated as response ratio was highest (15.67 kg grain per kg potassium applied) for application of potassium @ 30 kg K_2O ha^{-1} along with N and P which reveals the importance of potassium in balanced fertilization (Fig. 1). It is also observed from the Fig. 2 that the apparent recovery of N, P and K was improved considerably due to application of potassium. In view of lower use efficiency of the costly inputs like plant nutrients, their judicious use is very essential to reduce the cost of cultivation and to improve the profitability. The results thus clearly bring out the fact that although the black swell shrink soils are categorized

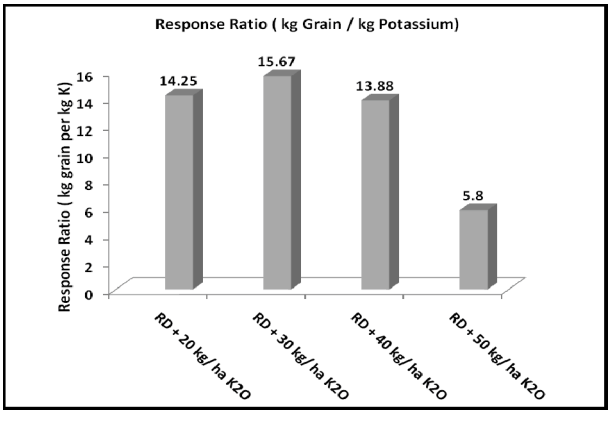

Fig. 1. Response ratio (kg grain per kg potassium) in chickpea

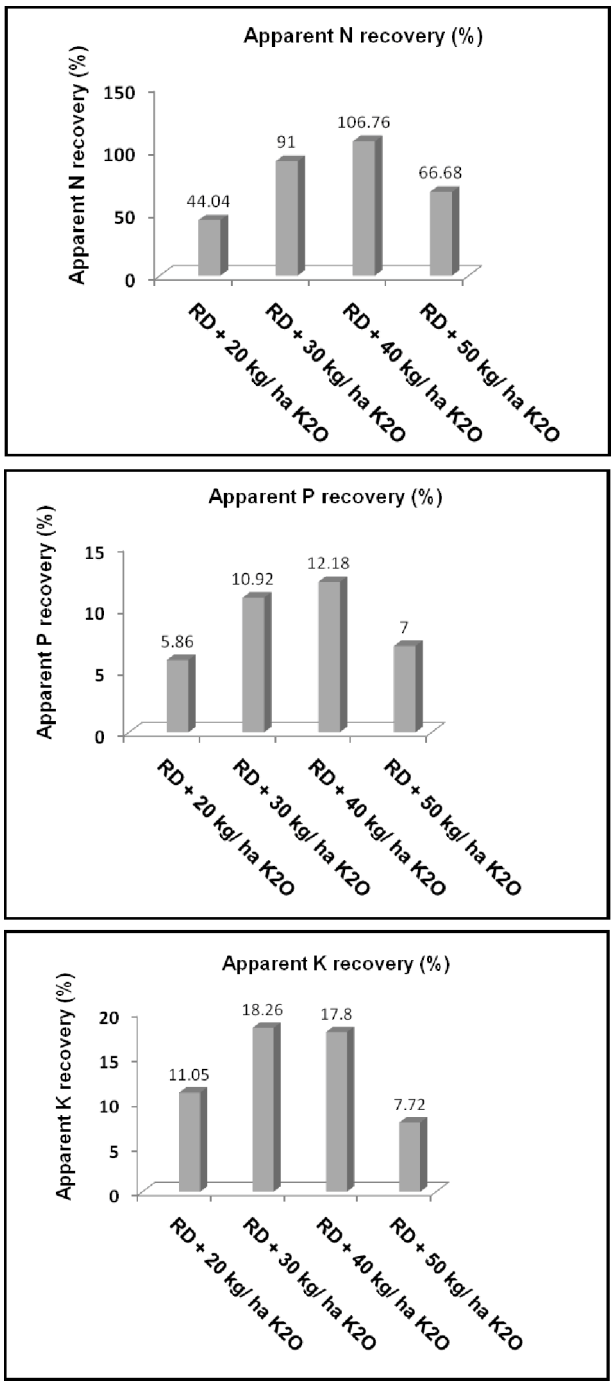

Fig. 2. Apperent recovery N, P and K

as high in potassium, the sustained crop productivity would need regular potassium application in order to ensure precise input use as well as prevent the soil potassium mining. The results further support that existing limits of categorizing fertility classes are based on very

Table 5. Net monetary returns and Benefit: cost ratio of chickpea (Pooled data for 2008-09 to 2010-11)

Treatment	NMR (Rs ha^{-1})	B : C Ratio
T_1 - Absolute control	28406	2.78
T_2-100 % RDF	35387	2.95
T_3- RDF*+ 20 Kg K_2O	41226	3.30
T_4- RDF+ 30 Kg K_2O	45255	3.54
T_5- RDF+ 40 Kg K_2O	46699	3.53
T_6- RDF+ 50 Kg K_2O	41220	3.26
T_7- RDF+ 2% KNO_3 (Once)	35184	2.71
T_8- RDF+ 2% KNO_3 (Twice)	37697	2.68
CD (P = 0.05)	**3545.34**	

old literature (Muhr *et al.,* 1965) and they are irrespective of soils and crops which need to be refined.

Economics of chickpea

The highest net monetary returns were obtained at 40 kg K_2O ha^{-1} closely followed by 30 kg K_2O ha^{-1} which were on par with each other (Table 5). The B:C ratio was highest (3.54) at 30 kg K_2O ha^{-1}. Thus the results of present study clearly indicated the benefit of balanced fertilization highlighting the necessity of conjoint use of major nutrients for optimum input use and profitability.

CONCLUSION

Application of potassium @ 30 kg K_2O ha^{-1} along with recommended N and P_2O_5 significantly increased the yield of chickpea and recorded response of chickpea to potassium up to 30 kg ha^{-1} along with improvement in residual soil fertility, growth and yield contributing characters, physical grain quality as well as protein content. Based on three years field experimentation, application of 30 kg K_2O ha^{-1} is recommended along with N and P_2O_5 (25:50 kg ha^{-1}) in medium deep black swell-shrink soils for obtaining higher yield and improving quality of chickpea as well as soil fertility. Application of two foliar sprays of potassium nitrate @ 2 per cent along with recommended N and P_2O_5 was also found beneficial for yield as compared to only N and P_2O_5 with no potassium.

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A GIS- Based Approach in Morphometric Analysis of Shegaon Watershed Chandrapur District, Maharashtra

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ABSTRACT

Morphometry is the measurement and mathematical analysis of the configuration of the earth's surface, shape anddimension of its landforms (Obi Reddy *et al.* 2002).Morphometry of drainage basin morphology reflects various geological and geomorphological processes over time, as indicated by various morphometric studies(Burrough and McDonnell1998; Hurtrez *et al.* 1999).Theinfluence of drainage morphometry is very significant inunderstandingthe landform processes, soil physical properties and erosional characteristics.

Drainage provides a basic to understand initial gradient, variation in rock resistance, structural control, geological and geomorphologic history of the drainage basin or watershed.The quantitative analysis of drainage system is an important aspect of characteristic of watershed (Strahler 1964). It is important in any hydrological investigation like assessment of groundwater potential, groundwater management, basin management and environmental assessment.Hydrologic and geomorphic processes occur within the watershed and morphometric characterization at the watershed scale reveals information regarding formation and development of land surface processes (Dar *et al.* 2013).The morphometric analysis is done successfully through measurement of linear, aerial, relief, gradient of channel network and contributing ground slope of the basin. (Chakraborty, 2003) Strahler's system of classification designates a segment with no tributaries as a first-order stream. Where two first-order stream segments join, they form a second-order stream segment and so on. The morphometric analysis of the drainage basin is aimed to acquire accurate data of measurable features of stream network of the drainage basin. Various hydrological phenomena can be correlated with the physiographic characteristics of an drainage basin such as size, shape, slope of the drainage area, drainage density, size and length of the contributories, etc. The remote sensing technique is the convenient method for morphometric analysis as the satellite images provide a synoptic view of a large area and is very useful in the analysis of drainage basin morphometry. The fast emerging spatial information technology, remote sensing, GIS, and GPS have effective tools to overcome most of the problems of land and water resources planning and management rather than conventional methods of data process (Rao*et al.* 2010).The present study aims at using the remote sensing andGIS technology to compute various parameters of morphometric characteristics of the Shegaon watershed in Chandrapur district of Maharashtra, India.

Shegaon watershed in Warora tehsil of Chandrapur district of Maharashtra located (Fig.1) between $20^0 18^l$ N to $20^0 22^l$ latitude and $79^0 05^l$ to $79^0 10^l$ E longitude. The total area is 2249.88 ha. The study area falls in the Survey of India Toposheet No.55P/3. Geologically the area mainly occupied by the Deccan basalts followed by sandstone/limestone of Lameta group of cretaceous period. Physiographically, watershed area was divided into six major physiographic units *viz.* isolated mound, subdued plateau, upper pediment, lower pediment, upper plain and lower plain. The mean elevation of area varies from 220 to 280 m above mean sea level (MSL) associated with moderately sloping (8-15%), gently sloping (3-8%), very gently sloping (1-3%), and nearly level (0 - 1%) sloping lands. The climate of the area is subtropical; dry sub-humid with ustic soil moisture regime and hyperthemic soil temperature regime. The average rainfall is 1200 mm which is received mostly from southern monsoon.

Digital data of IRS-P6 LISS-IV of February 2010 (Fig.1) along with LISS-III (October 2008) was geocoded using ARC-GIS 10.2. The toposheet was used to prepare

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base map for different landforms, generation of slope and drainage (Fig.2) for planning the traverse route for ground truth collection.Morphometric parameters *viz.* stream ordering, length, bifurcation ratio, drainage density, drainage frequency and intensity is assessed. Generally, cumulative length of stream of a particular order is measured and the mean length (Lu) of that order (u) is obtained by dividing cumulative stream length by number of segments of that order (Nu).The lower bifurcation ratio values are characteristic of the watershed which has suffered less structural disturbances (Strahler, 1964) and the drainage pattern has not been distorted because of the structural disturbances.

Stream ordering

The stream order is a measure of the position of a stream in the hierarchy of the tributaries. The data revealed that 51streams drain the watershed (Table 1) and highest number of streams (39) belongs to first order and number of streams decreased with increase in order. Shegaon watershed is fourth order stream. The first order streams observed in the upper reaches of the watershed where the terrain is at higher ridges and higher order streams noticed in the central and lower portion of watershed where the topography is plain *i.e.* higher number of streams observed in upper reaches of watershed and decreased towards lower reaches. More the number of streams in an area more the soil erosion and poor soil development and vice versa in upper reaches as compared to lower reaches

Stream length: Length of the stream is indicative of the contributing area of the basin of that order. It was observed that, total stream length decreased with increasing stream orders. It could attributed to decrease in number of streams with increasing orders, thus representing ideal conditions of watershed. The overall average stream length observed1.23 and 0.09 km from first order stream to fourth order stream, respectively. The highest stream length (5.71km) was noticed in third order streams.

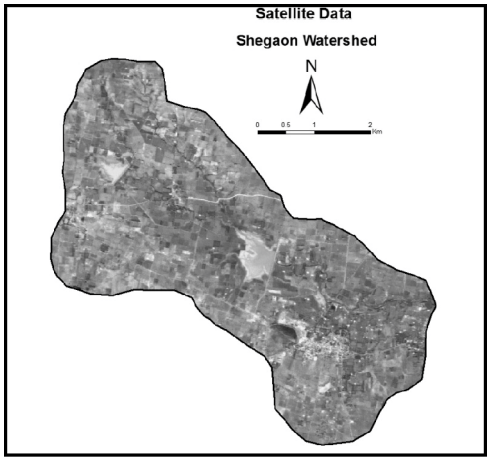

Fig. 1: IRS-P6 LISS IV satellite data of Shegaon watershed

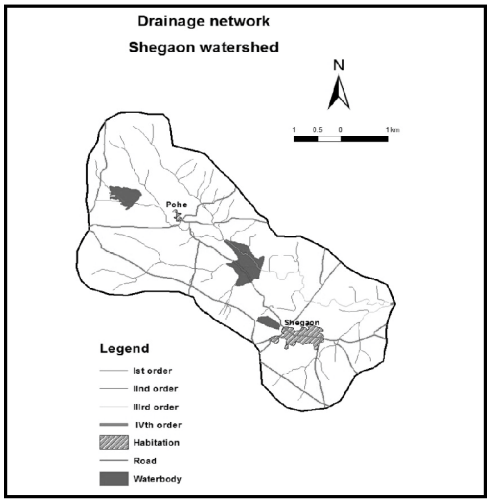

Fig.2: Drainage network map of Shegaon watershed

Table 1. Different parameters for morphometric analysis of Shegaon watershed

Area (km^2)	Perimeter (km)	Order (u)	Number (Nu)	Total stream length (km)	Average stream length (Lu) (km)	Bifurcation Ratio (Rb)	Drainage density (D) ($km\ km^{-2}$)	Drainage frequency (km^{-1})	Drainage intensity
22.89	22.09	1	39	24.10	1.23	4.33	1.90	2.22	4.21
		2	09	13.22	1.46	4.50			
		3	02	6.14	5.71	2.0			
		4	01	0.09	0.09	-			
Total	**-**	**51**	**43.55**	**8.49**	**-**				

Bifurcation ratio: The average bifurcation ratio calculated for watersheds which are more or less normal according to Horton's law, as they range between 2.0 and 4.5(Krishnamurthy *et al.*, 1996). The variation in Rb values are attributed to differences in their stages of geomorphic developments and topographic variations. A high overall bifurcation ratio (4.50) of the watershed in second order streams indicates structural disturbance owing to complex geological formations.

Drainage density, frequency and intensity: The high drainage density indicates rough surface implying shallow soils and more prone to erosion and vice versa. Low drainage density was observed in the region of highly resistant or permeable soil material under vegetative cover and low relief. The drainage density of the watershed was recorded 1.90 km km^{-2}, which is moderate with moderate drainage frequency (2.22 km^{-1}) indicating roughness of the area whiledrainage intensity noticed moderate. (4.21)The detailed morphometric study of the watershed shows dendritic to sub-dendritic drainage patterns, highest stream order frequency in case of first-order streams and second order. The drainage density values of the Shegaon watershed below five revealing that the subsurface area ispermeablewith characteristic feature of coarse drainage.

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On Farm Integrated Pest Management in Rice

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ABSTRACTS

Field experiment was conducted on integrated pest management (IPM) in rice by Agriculture Research Station, Sakoli, Dist. Bhandara during *Kharif* 2014 with an objective to manage pests (including insects, diseases and weeds) in a holistic way in farmers' fields involving them in a participatory way and allowing them to select IPM practices from a basket of options available. The IPM comprising seed treatment with Carbandezim 50 per cent WP @ 2 g kg^{-1} seed, application of Carbofuran 3 G @ 1.1 kg a.i. ha^{-1} 5 days before pulling seedlings, seedlings transplanted at spacing of 20 x 15 cm, alleyways of 30 cm after every 10 rows, application of Butachlor @ 1.5 kg a.i. ha^{-1} on 5th day after transplanting + 1 manual weeding, installation of pheromone traps (Scirpoload) @ 8 traps ha^{-1} for stem borer monitoring, application of Carbofuron 3 G @ 25 kg ha^{-1}, application of Cartap hydrochloride 50 WP @ 600 g ha^{-1} at 60 DAT, application of Propiconazole 0.1per cent and mid season drainage found good with low incidence of weeds and white ear head (2.66 %), reduced severity of all the diseases like neck blast, sheath rot and brown spot.

Rice (*Oryza sativa* L.) is the global staple food of more than half of the human population. Intensive cultivation of rice has resulted in the frequent occurrence of biotic stresses that formed a major constraint in rice production. Indiscriminate and rampant use of insecticides had no effect on yield and yield contributing characters of rice, when insect pests infestation is below ETL. So, farmers could avoid injudicious use of insecticides, which ultimately save input cost and protect the environment from insecticidal pollution as well (Bari *et al.,* 2015). To overcome these problems efficiently, adoption of integrated pest management in a participatory mode is the primary option. Earlier efforts have been made for evaluation and validation of integrated pest management practices in rice (Karthikeyan *et al.,* 2010, Elakkiya and Sujeetha, 2011, Chakraborty, 2012, Visalakshmi *et al.,* 2013 and Anonymous, 2014). Therefore, a trial on integrated pest management (IPMs) in rice was conducted at Sakoli, Dist. Bhandara during *Kharif* 2014 with an objective to manage pests (including insects, diseases and weeds) in a holistic way in farmers' fields involving them in a participatory way and allowing them to select IPM practices from a basket of options available.

MATERIAL AND METHODS

IPM trial was conducted on the field of Shri. Anil Shanker Gahane at Sakoli village in Bhandara district, Maharashtra, during *Kharif* 2014. Variety Jai Ram (Local) was grown in both IPM and farmers' practice plots at 0.40 ha area each. Depending on the pest incidence IPM components were used in IPM plots while farmers practices included schedule based operations. The packages of practices were followed in each block as given below:

A) IPM

Nursery

1. Seed treated with Carbandezim 50 per cent WP @ 2 g kg^{-1} seed.
2. Applied Carbofuran 3 G @ 1.1kg a.i. ha^{-1} 5 days before pulling seedlings.

Main field (After Transplanting)

3. Seedlings transplanted at spacing of 20 x 15 cm.
4. Alleyways of 30 cm after every 10 rows.
5. Applied Butachlor @ 1.5 kg a.i. ha^{-1} on 5th day after transplanting + 1 manual weeding.
6. Pheromone traps (Scirpoload) were installed @ 8 traps ha^{-1} for stem borer monitoring.
7. Applied Carbofuron 3 G @ 25 kg ha^{-1} at 37 DAT.
8. Applied Cartap hydrochloride 50 WP @ 600 g ha^{-1} at 60 DAT.
9. Applied Propiconazole 0.1% at 71DAT.

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10. Mid season drainage was followed

B) Farmers practices

Nursery

1. Seed treated with Carbandezim 50% WP @ 1 g/ kg seed.

Main field (After Transplanting)

2. Seedlings were transplanted randomly
3. Applied Butachlor @ 0.5 kg a.i./ha on 5th day after transplanting + 1 manual weeding.
4. Applied Carbofuron 3 G @ 25 kg/ha at 37 DAT.

Starting from 15 DAT, observations on pest incidence were recorded on 5 randomly selected hills in each replication (25 hills/each block) at weekly interval. Observations on number of tillers damaged by stem borers (dead heart/white ear head), gall midge (silver shoot), number of leaf folder damaged leaves and number of plant hoppers per hills were recorded from the selected hills. Incidence of major diseases was also recorded. Weed number and weed biomass per m^2 was also observed. Yield was recorded from 5 x 5 m^2 plot from each replication.

RESULTS AND DISCUSSION

Incidence of stem borer, leaf folder, brown plant hopper, white backed plant hopper, green leaf hopper, leaf blast, neck blast, sheath blight, sheath rot, brown spot and bacterial leaf blight was observed but none of them crossed ETL either in Farmer practices or in IPM plots. However, low incidence (2.66%) of white ear head (stem borer) was noticed in IPM plot as against 9.94% in farmers practice at pre harvest stage might be one of the reasons for increased yield in IPM plot. Adoption of IPM practices reduced the severity of all the diseases except bacterial leaf blight. The data on weed population and weed biomass were recorded at 30 and 60 DAT. The weed population was 53.8% to 63% higher in farmers practice plots and weed biomass was 20.45% to 21.67% higher, as compared to IPM plot. BC ratio was similar in both the plots (2.90 – 2.94) due to good yield and high returns.

The present findings are in accordance with Dash *et al.* (2006) who found IPM module was best for irrigated rice against major insect pests and for getting highest yield and highest number of spiders in Sambalpur, Orrisa. Similarly, Tripathy and Kanungo (2008) demonstrated IPM technology in Kulei village of Anguli district of Odisha and revealed lower incidence of stem borer and BPH and higher monetary benefit in IPM farmers field than non IPM farmers' field. Samiayyan *et al.* (2010) also confirmed that adoption of rice IPM module resulted in significantly higher yield, more natural enemies and lesser pests than the farmers practice. Jena *et al.* (2012) found lower incidence of insect pests of rice and highest grain yield in chemical + non chemical module in comparison with farmers' practice. Nalini *et al.* (2013) evaluated IPDM module in four villages at Madurai East block and revealed that insect pests such as brown plant hopper, white backed plant hopper, stem borer, leaf folder, gall midge and bacterial leaf blight disease decreased and higher grain yield and cost benefit ratio were recorded in IPDM module compared to farmer's practice.

CONCLUSIONS

Low incidence of white ear head at pre harvest stage and diseases in IPM plot as compared to farmers practice might be one of the reasons for increased grain yield. Adoption of IPM practices reduced area under disease progress curve (AUDPC) of major diseases like neck blast, sheath rot and brown spot. Weed population and weed biomass were considerably reduced in IPM implemented plots as compared to farmer's practice resulting in increased grain yields. The present study needs further research for conformation and validation.

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Table :Effect of IPM and farmers practices on insect pests and diseases incidence, grain yield of rice and benefit cost ratio.

Treatments	Stem borer			Gall midge		Leaf Folder	Population per 5hills				
	% Dead Heart		%White Earhead	% Silver Shoot		% Damage)	Brown Plant Hopper		White Backed Plant Hopper		Green Leaf Hopper
	78DAT	92DAT	Preharvest	64DAT	92DAT	71DAT	92DAT	99DAT	92DAT	99DAT	85DAT
IPM	7.48	9.86	2.66	7.05	10.12	6.14	15.60	15.40	22.4	19.80	8.00
Farmerspractice (FP)	8.02	7.90	9.94	9.68	7.17	5.88	14.20	17.20	19.20	26.20	9.20

Table : Contd……

Treatments	Area under disease progress curve (AUDPC)							Weed population (No./ m^2)		Weed biomass (dry wt. g/m^2)	
	Leaf Blast	Neck blast	Sheath blight	Sheath rot	Brown Spot	Stem rot	Bacterial leaf blight	30DAT	60DAT	30DAT	60DAT
IPM	17.64	286.30	44.80	322.70	1.40	343.70	1122.10	11.60	9.80	17.74	17.98
Farmers practice (FP)	18.48	338.80	57.40	462.70	23.80	611.80	1096.20	31.80	21.20	22.30	22.96

Table : Contd……

Treatments	Yield(q/ha)	Grossreturn(Rs.)	Cost of cultivation(Rs.)	Net returns(Rs.)	B:Cratio
IPM	57.84	98331	33938	64393	2.90
Farmers practice (FP)	50.19	85318	29004	56314	2.94

Price of Paddy = Rs.1700 /q

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Antagonistic Activities of Native *Bacillus* and *Pseudomonas* Isolates Against Soil Borne Pathogens of Pigeonpea

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ABSTRACT

Rhizospheric soil samples collected from different locations exhibited nine Bacterial isolates degrading chitin on colloidal chitin agar media. Based on morphological and cultural characteristics isolates were categorised as *Pseudomonas* (PS_1 to PS_4) and *Bacillus* (BS_1 to BS_5). All the isolates were found effective against *Fusarium udum, Rhizoctonia bataticola* and *Sclerotium rolfsii*, when tested by dual culture technique. The PS_3 of *Pseudomonas* from Anjangaon and BS_2 of *Bacillus* from Akot exhibited maximum antagonistic activity among all isolates against *F. udum* inhibiting the pathogen by 93.71 and 72.13 per cent respectively. *R. bataticola* was inhibited by 89.91 and 78.36 per cent respectively by BS_2 and PS_3. In case of *S. rolfsii* BS_1 and PS_2 exhibited maximum percent growth inhibition *i.e.* 88.33 and 64.21 percent respectively. *Pseudomonas* and *Bacillus* isolates were highly sensitive to thiram alone and carboxin + thiram (combined product). Isolates PS_1 of *Pseudomonas* from Akola was least sensitive to carbendazim exhibiting 40.28% inhibition and pendimethalin, where the isolate was inhibited by 24.13% the maximum being in isolate PS_3 from Anjangaon with 70.43% inhibition due to pendimethalin. Overall insecticides and weedicides were less toxic to the isolates of all the isolates compared to fungicides. Isolate BS_2 of *Bacillus* obtained from Akot proved best among all the isolates in inhibiting the growth of *F. udum* , *R. bataticola* and *S. rolfsii.*

Pigeonpea (*Cajanus cajan* (L.) Millsp.) also known as red gram, arhar and tur is second most pulse of India next to gram and in Maharashtra 32.37% of area is covered under the pigeonpea crop. Arhar crop in Maharashtra during 2014-15 was about 2780 thousand MT sharing 16.16% of total production. Generally grown in *kharif*, the crop suffers from various diseases viz., wilt, root rot, collar rot, stem canker, bacterial blight and sterility mosaic. But the wilt disease caused by *Fusarium udum* is the worst disease of pigeonpea in India, especially in Maharashtra, Madhya Pradesh, Uttar Pradesh, Bihar and Tamil nadu. The causal organisms of wilt was identified as *Fusarium oxysporum* f. sp. *udum* by Butler (1906). Biocontrol has a vast potential for the management of soil borne pathogens. Moreover there are numerous native rhizospheric organisms which can be exploited as potential biocontrol against soil borne pathogens. The isolation of chitinase activity showing rhizobacteria against *F. udum* helps in reduction of pathogens having chitin in their cell wall in pigeonpea rhizosphere and the present investigation was therefore, conducted to study efficacy of native rhizobacterial isolates *i.e Bacillus* and *Pseudomonas* against *F. udum* and other root disease causing organisms like *R. bataticola and S. rolfsii* and to test the sensitivity of these rhizobacteria against commonly used chemicals.

MATERIAL AND METHODS

Healthy and wilt infected soil sample were collected from different locations of Akola and nearby region from root zones of healthy and infected plants at the depth of 15-20 cm. Composite samples were prepared by mixing soil samples collected from respective field. Soil samples were collected from different places were used for isolation of bacteria by serial dilution method. Soils were serially diluted with sterile water until a dilution of 10^5 colony forming units(CFU) g^{-1} of soils, inoculated on colloidal chitin (CC) agar medium containing Colloidal chitin(5g), Na_2HPO_4 (2g), KH_2PO_4 (1g), NaCl (0.5g), NH_4Cl (1g), $MgSO_4$ $7H_2O$ (0.5g), $CaCl_2$ $2H_2O$ (0.5g), yeast extract(0.5g), agar(20g) and distilled water(1000 ml) and incubated at room temperature for 7 days. Strains exhibiting a clear zone (degradation of chitin) around the colony were picked and identified after mounting on slides under microscope, were used The Gram staining and morphology for identification of bacteria and were purified on NA media adopted by Velusamy and Das (2014). Pigeonpea plants showing symptoms of wilt, root rot and collar rot were collected and used for isolation of *F. udum, R. bataticola* and *S. rolfsii* (pathogens) respectively on the PDA medium. Dual culture technique was adopted for estimating the ability of rhizospheric organisms as an

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antagonist against *F. udum, R. bataticola* and *S. rolfsii*. The tests were carried out on PDA medium The plate were incubated at 28±2 ^{0} C for 5 days and then inhibition of mycelial growth of pathogen was measured. Antagonistic effect was expressed as zone of inhibition by subtracting colony diameter of the fungus from the control. Control plates were run without antagonistic organism. Poison food technique was employed to test the sensitivity of bioagents to different fungicides, weedicides and insecticides with following chemicals details from fungicides class thiram 0.3 per cent, carbendazim 0.1per cent and carboxin + thiram (combined product) 0.3 per cent, from Insecticides class imidacloprid 0.4 per cent and thiomethoxom 0.4 per cent, from Weedicides class imazethapyr 0.3 per cent and pendimethalin 0.7 per cent were used with their respective concentrations were incorporated in warm NA Medium before pouring in plates. Five plates of each chemicals were inoculated with 1ml bacterial broth suspension from 7th dilution. The plates were incubated for 1-2 days. Control plates were run without chemicals. CFU were measured after 24-48hr of incubation and sensitivity was judged based on population in control.

RESULTS AND DISCUSSION

In vitro efficacy of *Pseudomonas* isolates against *F. udum, R. bataticola* and *S. rolfsii*

During recent era antagonistic technique relates to bacteria *Pseudomonas* isolates plays an important role for management of various seed borne, soil borne and airborne disease. Role of *Pseudomonas* against *F. udum*, revealed significant achievement as depicted in table1 Among four isolates PS_3 from Anjangoan was found to be effective against *F. udum* exhibiting 72.13 per cent inhibition allowing 25.08mm mycelial growth of pathogen followed by PS_4, PS_2 and PS_1 with inhibition of 70.97, 68.9 and 66.51 per cent restricting the growth upto 26.12 mm, 27.99 mm and 30.14 mm of pathogen respectively.

In regard to *R. bataticola* also highest efficiency was recorded due to PS_3 as 78.36 per cent inhibition with 19.47 mm mycelial growth of pathogen was noted followed by PS_1 with 76 per cent inhibition and 21.60 mm growth of *R. bataticola*. *S. rolfsii* was arrested maximum due to application of PS_2 (Akola) to the extent of 64.21 per cent with mycelial growth of 32.21 mm of pathogen followed by 63.91 per cent due to PS_3 with 32.48 mm growth of pathogen and PS_1 with 61.86 per cent inhibition. Three isolates *i.e.* PS_1, PS_2, and PS_3 were at equal level of effectiveness for reducing the growth of test pathogen. Least inhibition was noted in PS_4 (44.12%) with 50.29 mm growth of pathogen as tested on 1per cent level of significance.

Pseudomonas proved an efficient bioagent for restricting the growth of tested pathogen. Various workers have published their results which supports the present findings. Goudar and Kulkarni (2000) studied the antagonistic nature of *Pseudomonas fluorescence* and found 81.87 percent inhibition due to *P. fluorescence*. Asha *et al.* (2011) isolated ten isolates of *P. fluorescens* from rhizosphere soil samples collected from various tomato growing fields, evaluated their efficacy in increasing seed quality variables of tomato and in inhibiting the mycelial growth of *Fusarium oxysporum* and observed *Pseudomonas* isolate 2 produced effective results to increase seedling emergence and reduce *Fusarium* wilt disease incidence. Manjunatha *et al.* (2012) isolated 92 isolates of fluorescent *Pseudomonas* from the rhizosphere soil of chilli, sunflower, redgram, groundnut, fieldbean, greengram, brinjal, tomato, burmuda grass, beans, sorghum, paddy and sesame Among these isolates *P. fluorescens* Pf4 showed maximum inhibition of mycelial growth of *Macrophomina phaseolina* (21.30%), *R. bataticola* (24.07%), *Rhizoctonia solani* (32.96%), *F. oxysporum*. f.sp. *udum* (48.14%), *C. gloeosporioides* (41.67%), *F. solani* (24.07%), *Sclerotium rolfsii* (40.74%), *Cercospora capsicii* (21.67%), *Alternaria sesami* (20.00%) and *Xanthomonas axonopodis* pv. *punicae* (1.84 mm) by dual plate technique. Nehra *et al.* (2012), and Sujatha and Ammani (2013) reported the efficiency of *Pseudomonas* against *F. udum* and various pathogen causing disease. The disease reduction might be due to release of biochemical hydrolysis and production of toxins which inhibit the pathogen. Kaswate *et al.* (2003) revealed that *P. fluorescens* was the effective in inhibiting various isolates of *R. bataticola* (73.98%).

In vitro Efficacy of *Bacillus* isolates against *F. udum, R. bataticola* and *S. rolfsii*

Bacterial antagonist are able to minimize growth of fungus causing disease in pigeonpea. Among five isolates of *Bacillus* BS_2 (Akot) allowing only 5.66 mm mycelial growth with 93.71per cent inhibition of *F. udum* was best followed by BS_4, BS_5, BS_3 and BS_1 (Table 2). Isolates BS_2, BS_4 and BS_5 were at par with each other at 1 per cent level of significance in controlling the growth of

Table 1. Efficacy of *Pseudomonas* isolates against *F. udum*, *R. bataticola* and *S. rolfsii*

Pseudomonas isolates	*F. udum*		*R. bataticola*		*S. rolfsii*	
	Colony diameter (mm)	Percent growth inhibition	Colony diameter (mm)	Percent growth inhibition	Colony diameter (mm)	Percent growth inhibition
PS_1	30.14	66.51	21.60	76.00	34.32	61.86
PS_2	27.99	68.90	24.43	72.85	32.21	64.21
PS_3	25.08	72.13	19.47	78.36	32.48	63.91
PS_4	26.12	70.97	31.15	65.38	50.29	44.12
Control	90.00	00	90.00	00	90.00	00
SE(m)±	0.18	-	0.14	-	0.17	-
CD(P=0.01)	0.90	-	0.69	-	0.87	-

Table 2. Efficacy of *Bacillus* isolates against *F. udum*, *R. bataticola* and *S. rolfsii*

Bacillus isolates	*F. udum*		*R. bataticola*		*S. rolfsii*	
	Colony diameter (mm)	Percent growth inhibition	Colony diameter (mm)	Percent growth inhibition	Colony diameter (mm)	Percent growth inhibition
BS_1	10.50	88.33	21.95	75.61	10.50	88.33
BS_2	5.66	93.71	9.08	89.91	18.30	79.66
BS_3	8.33	90.74	19.31	78.54	12.80	85.77
BS_4	7.16	92.04	26.00	71.11	17.15	80.94
BS_5	7.66	91.48	27.70	69.22	22.83	74.63
Control	90.00	00	90.00	00	90.00	00
SE(m)±	0.62	-	0.23	-	0.25	-
CD(P=0.01)	2.71	-	1.19	-	1.28	-

F. udum. All isolates exhibited higher inhibitory effect which ranged between 88.33 to 93.71per cent against pathogen.

Similar trend of antagonism was achieved against *R. bataticola* due to *Bacillus* isolates. Maximum effect was noted due to BS_2 with 9.08 mm growth of pathogen and 89.91% inhibition followed by 18.30 mm and 78.54 per cent inhibition by BS_3. Higher efficiency with 88.33 per cent inhibition was noted due to BS_1 against *S. rolfsii* where the pathogen could grew only upto 10.50 mm as against 90 mm without antagonist followed by BS_3 with 85.77 per cent growth inhibition of pathogen. All isolates were statistically significant over control. Due to secretion of toxic elements by bacteria they proved to be an efficient biocontrol agent.

Gouder and Kulkarni (2000) reported the effectiveness of *Bacillus subtilis* stating that it could inhibit the growth of pathogenic fungi causing disease in field crops. Kaswate *et al.* (2003) revealed that *B. subtilis* was effective in inhibition of various isolates of *R. bataticola*. Siddiqui and Shakeel (2007) isolated twenty unidentified *Bacillus* species from pathogen-suppressive soils of pigeonpea field for control of wilt disease complex caused by *Heterodera cajani*, *Melydogyne incognita* and *F. udum*. Among them five isolates (B602, B603, B605, B615 and B618) were considered to have potential antifungal activity and inhibitory effect. Jadhav *et al.* (2014) collected five isolates from rhizosphere of infected pigeonpea plant

Table 3 : Sensitivity of *Pseudomonas* isolates to pesticides

Pseudomonas	CFU of *Pseudomonas* isolates×10^7														
	CFU in isolates control	Imidacloprid (0.4%)		Thiomethoxom (0.4%)		Carboxin+Thiram (0.3%)		Thiram (0.3%)		Carbendazim (0.3%)		Pendimethalin (0.7%)		Imazethypr (0.3%)	
		CFU	% reduction	CFU	% reduction	CFU	% eduction	CFU	% reduction	CFU	% eduction	CFU	% reduction	CFU	% reduction
PS_1	92.66	54.60	41.07	31.66	65.83	0	100	0	100	55.33	40.28	70.30	24.13	50.60	45.40
PS_2	99.33	29.00	70.80	25.33	74.50	0	100	0	100	54.66	44.97	61.35	38.23	54.00	45.63
PS_3	100.33	25.60	74.48	51.60	48.56	0	100	0	100	49.35	50.81	29.66	70.43	51.30	48.86
PS_4	87.00	66.30	23.80	30.00	65.51	0	100	0	100	48.00	44.82	39.00	55.17	58.60	32.64
SE(m)±	-	0.05	-	0.24	-	00	-	00	-	0.01	-	0.01	-	0.02	-
CD (P=0.01)	-	0.23	-	1.17	-	00	-	00	-	0.05	-	0.06	-	0.13	-

Table 4 : Sensitivity of *Bacillus* isolates to pesticides

Bacillus isolates	CFU of *Bacillus* isolates ×10^7														
	CFU in isolates control	Imidacloprid (0.4%)		Thiomethoxom (0.4%)		Carboxin+Thiram (0.3%)		Thiram (0.3%)		Carbendazim (0.3%)		Pendimethalin (0.7%)		Imazethypr (0.3%)	
		CFU	% reduction	CFU	% reduction	CFU	% eduction	CFU	% reduction	CFU	% eduction	CFU	% reduction	CFU	% reduction
BS_1	140.66	52.30	62.81	17.08	87.85	00	100	00	100	80.66	42.65	83.30	40.77	45.33	67.77
BS_2	99.33	57.00	42.61	46.00	53.68	00	100	0	100	57.36	42.25	77.59	21.88	25.30	74.52
BS_3	98.66	60.05	39.13	43.30	56.11	00	100	0	100	56.02	43.21	47.00	52.36	44.66	54.73
BS_4	109.00	54.60	49.90	37.76	65.35	00	100	0	100	33.51	69.25	54.66	49.85	55.06	49.48
BS_5	95.66	48.12	49.69	44.60	53.37	00	100	0	100	60.32	36.94	49.64	48.10	63.33	33.79
SE(m)±	-	0.21	-	0.03	-	-	-	-	-	0.01	-	0.01	-	0.03	-
CD (P=0.01)	-	0.96	-	0.11	-	-	-	-	-	0.06	-	0.04	-	0.10	-

and all were able to reduce the wilt. These observations supports the present data as earlier workers also found variation in antagonistic ability among isolates of *Bacillus*.

Sensitivity of bacterial isolates to pesticides

***In vitro* effect of pesticides on growth of *Pseudomonas* isolates**

Sensitivity of bacterial bioagent, *Pseudomonas* was tested against recommended doses of new seed dressing fungicides, insecticide and some weedicide used in cultivation. Colony forming units were assessed in media incorporated with these chemicals. Among four isolates of *Pseudomonas,* PS_4 (Anjangoan) exhibited maximum no of cfu *i.e.* 66.3×10^{-7} compared to 87.00×10^{-7} in control thereby giving 23.8 per cent inhibition due to imidacloprid. Other isolates were inhibited by 41.07, 70.8 and 74.48 per cent due to this insecticides. Another insecticide *i.e.* thiomethoxom reduced the cfu of *Pseudomonas* from 48.5 to 74.5 per cent. Fungicides carboxin + thiram as well as thiram alone completely inhibited the growth of *Pseudomonas* exhibiting 100 per cent inhibition of all the isolates in these fungicides, whereas carbendazim reduced its colonies to the extent of 55.33×10^{-7}. These results are surprising as fungicides had shown detrimental effect on bacterial bioagent which is against the general practice of using bacterial bioagent along with fungicides. Pendimethalin toxicity was found to be less harmful against PS_1 and PS_2 exhibiting 24.1 and 38.23 per cent inhibition whereas PS_3 and PS_4 were having more 50 per cent inhibition of *Pseudomonas*. Imazethypr supported then 50 per cent survival *i.e.* number of colonies of all isolates of *Pseudomonas* and can be categorised as safer for *Pseudomonas*. Although the sensitivity of fungicide was might be due to different isolates of bioagent, this trend needs further confirmation with other isolates of *Pseudomonas*.

***In vitro* effect of pesticides on growth of *Bacillus* isolates**

Bacillus generally use as seed treater for reducing some soil/seed borne pathogens, colony forming units affected due to pesticides are noted in table 4. Isolate BS_3 recorded highest cfu *i.e.* 60.05×10^{-7} which was being lowest *i.e.* 48.12×10^{-7} in BS_5. Thiomethoxom was found non tolerable as less than 50 per cent viable in this chemical colonies were observed. Isolate BS_2 was least sensitive to thiomethoxom with 53.68 per cent inhibition. Combined product of carboxin + thiram and thiram alone was completely toxic to all isolates of *Bacillus* while carbendazim exhibited maximum inhibition of 69.25% in BS_4. The least sensitive isolate to fungicide was observed as BS5 with 36.94 per cent inhibition.

Weedicide Pendimethalin in most cases supported more than 50 per cent growth of *Bacillus* isolates except in BS_3 where inhibition was 52.36 per cent, while in imazethypr it was quite incompatible for this bioagent thereby reducing its population upto 74.52 per cent in BS_2. Other two isolates *i.e.* BS_1 and BS_3 also exhibited more than 50 per cent reduction in cfu. *In vitro* studies clearly established that *Bacillus* spp were compatible with recommended dose of pesticides but in some cases *i.e.* in combined product of carboxin + thiram and thiram alone the bioagent was sensitive, Shetti *et al.* (2014) studied the biodegradation ability of soil bacterium *Bacillus weihenstephanensis* to imidacloprid, they showed that *Bacillus* was able to degrade (78%) imidacloprid within four weeks of incubation. Comparatively less toxic effect of insecticides and weedicides on *Bacillus* is also recorded in present study.

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Farmers Preferences for Trees Under Different Agroforestry Systems in Akola District of Maharashtra

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ABSTRACT

The present study was undertaken to assess farmers preferences for trees under different agroforestry practices followed by the farmers in Akola district during 2013-15. The list of 100 respondents from 10 villages of Patur tehsil were selected randomly where 10 farmers from each village were selected for the study. Exploratory design of social research, has been used.Vegetation analysis was done through quadrate sampling methods with 0.1% sample. The survey was conducted and data are collected by interview method using semi-structural questionnaire. Results revealed that the farmers are practicing eleven different agroforestry systems in their field namely: bund plantation, boundary planting, agrisilviculture, hortisilviculture, agrisilvipastoral, agrihortisilviculture, plantation along irrigation canal, kitchen garden, plantation near water sources, block plantation and scattered plantation.The use of the trees and local needs type of trees preferred by respondents are divided into six category namely; fuel wood yielding species, timber yielding species,Fruit yielding species, fodder yielding species, multipurpose tree species and short duration of species were more preferred by farmers in the ten selected villages of Patur tehsil of Akola district of Maharashtra in rainfed and irrigated situations.

Trees play prominent roles in agroforestry. Hudson (1945) stated that the increase in the living standard means there is certainly going to be a great increase in the requirements of forest products mainly timber for housing, wood for fuel, paper for the great masses of people who are being taught how to read and write, packaging cases for industrial products and in numerable other purposes. Therefore, the need to reforest through agroforestry in order to meet the growing demand for food medicinal herbs, fuel wood and timber cannot be over emphasized.

According to Alao (2005) plantation technology in Nigeria is a dying vocation. Nigeria's timber reserves have diminished rapidly. Supply can no longer cope with demand. There is a yearning gap between production and supply. Olujobi (2005) stated that the pressure on the available arable land has resulted into soil nutrient depletion, land degradation and substantial crop yield decline. Considering the importance of agroforestry in the provision of food and other basic needs (i.e fuel wood, staking materials, fibres, timber, medicinal concentrates, oils, fruits, and fodder for animals) for a large proportion of the rural population as well as its role in soil fertility restoration and the control of weeds and environmental degradation, a critical survey of the system will be necessary so as to identity the traditional agroforestry trees among farmers and then document them for future development.

Agro forestry has gained much importance during last five years since firewood, fodder, timber and other natural resources and exhausting very fast due to tremendous desforestation all over the country. In Maharashtra, per capita forest area is only 0.12 hectare(Anonymous,1981). To overcome the alarming situation of the forests, all India Coordinated Research Project on Agroforestry has been started from 1986 with wider objectives. One of its centers is at Dr. Panjabrao Krishi Vidyapeeth Akola.

In vidharbha there are three Eco zones namely eastern, central and western vidharbha zone. The area of Akola district falls under western in vidharbha region of Maharashtra. The documentation of such traditional agroforestry systems will help in building the knowledge treasure of the science of agroforestry. It will be helpful in implementing some of the most promising agroforestry models directly on the farmer's fields. In Akola district dry land agriculture is the predominant land use systems in dry tract. Trees are found on the farm lands in the form of traditional agroforestry systems combing the use of trees and shrubs with crops and livestock production.

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MATERIAL AND METHODS

The present study was conducted in Patur tehsil of Akola district in Vidarbha region of Maharashtra. Akola is a central part of the Amravati division. The district boundary latitude are 20° 42' N latitude and 77° 02' E longitude . The climate is tropical with temperature ranging from 10°C to 48°C and the annual rainfall from750 to 950 mm. The total area of Akola district in Vidarbha region of Maharashtra is 54341 km . The district has seven tehsils namely, Akot, Balapur, Patur, Barshitakli, Murtizapur, and Akola. Out of seven tehsil, Patur tehsil has been purposively selected for the study, because of the abundance in the vegetation in and around villages. Ten villages from Patur tehsil namely Shirla Andhare, Aastul, Pastul, Kothari (Khurd), Kothari (Budruk), Khanapur, Deulgaon, Bodakha, Malrajura and Sawarkhed were selected for the study. For the present study exploratory design of social research was used.The map of study area is given in Fig 1. Agroforestry survey was conducted to understand the different agroforestry practices followed by farmers in their field regarding types of trees, preferred composition and diversity.The data was collected carefully, examined before tabulation and simple statatistical tools/method were used.

Table 1. Agroforestry practices followed by farmers in Patur tehsil of Akola district under Maharashtra.

S.N.	Agroforestry Practices followed by farmers	Average		Tree Preferred by farmers
		R	I	
1	Bund plantation	72	0	**Tree** :- *Tectona grandis Azadirachta indica*
2	Boundary planting	84	0	**Tree:-** *Tectona grandis, Azadirachta indica, , Terminalia bellerica, Dalbergia sissoo, Butea monosperma, Acacia catechu, Aegle marmelos , Tamarindus indica , Casuarina equisetifolia , Emblica officinalis , Acacia arabica, Ziziphus mauritiana, Semecarpus anacardium.*
3	Agri-silviculture	66	9	**Tree**:-*Tectona grandis.*
4	Horti-silviculture	0	69	**Tree:-** *Tectona grandis.* **Fruit trees:-** *Punica garanatum, Magnifera indica, Citrus aunrantifolia, Psidium guajava, Citrus reticulata, Annona squamosa, Musa paradisiaca.*
5	Agri-silvi-pastoral	11	0	**Tree:-** *Tectona grandis Azadirachta indica, Ziziphus mauritiana.* **Grasses :-** *Pennisetum purpureum* and *Dichanthium annulatum.*
6	Agri-horti-silviculture	0	1	**Tree:-** *Tectona grandis.* **Fruit trees:-** *Pisidium gujava, Mangifera indica.*
7	Block plantation	0	1	**Tree:-** *Tectona grandis.*
8	Scattered plantation	1	0	**Tree:-** *Butea monosperma* and *Azadirachata indica.* **Fruit trees** :- *Mangifera indica.*
9	Planting along irrigation canal	0	27	**Tree:-** *Azadirachta indica and Ziziphus mauritiana.* **Fruit trees:-** *Pisidium gujava, , Mangifera indica.*
10	Kitchen garden	0	27	**Fruit trees:-** *Mangifera indica, Punica grantum and Citrus aurantifolia.*
11	Plantation near water sources	0	22	**Fruit trees:-** *Citrus reticulata*

R – Rainfed Agroecosystem. I – Iriigated Agroecosystem

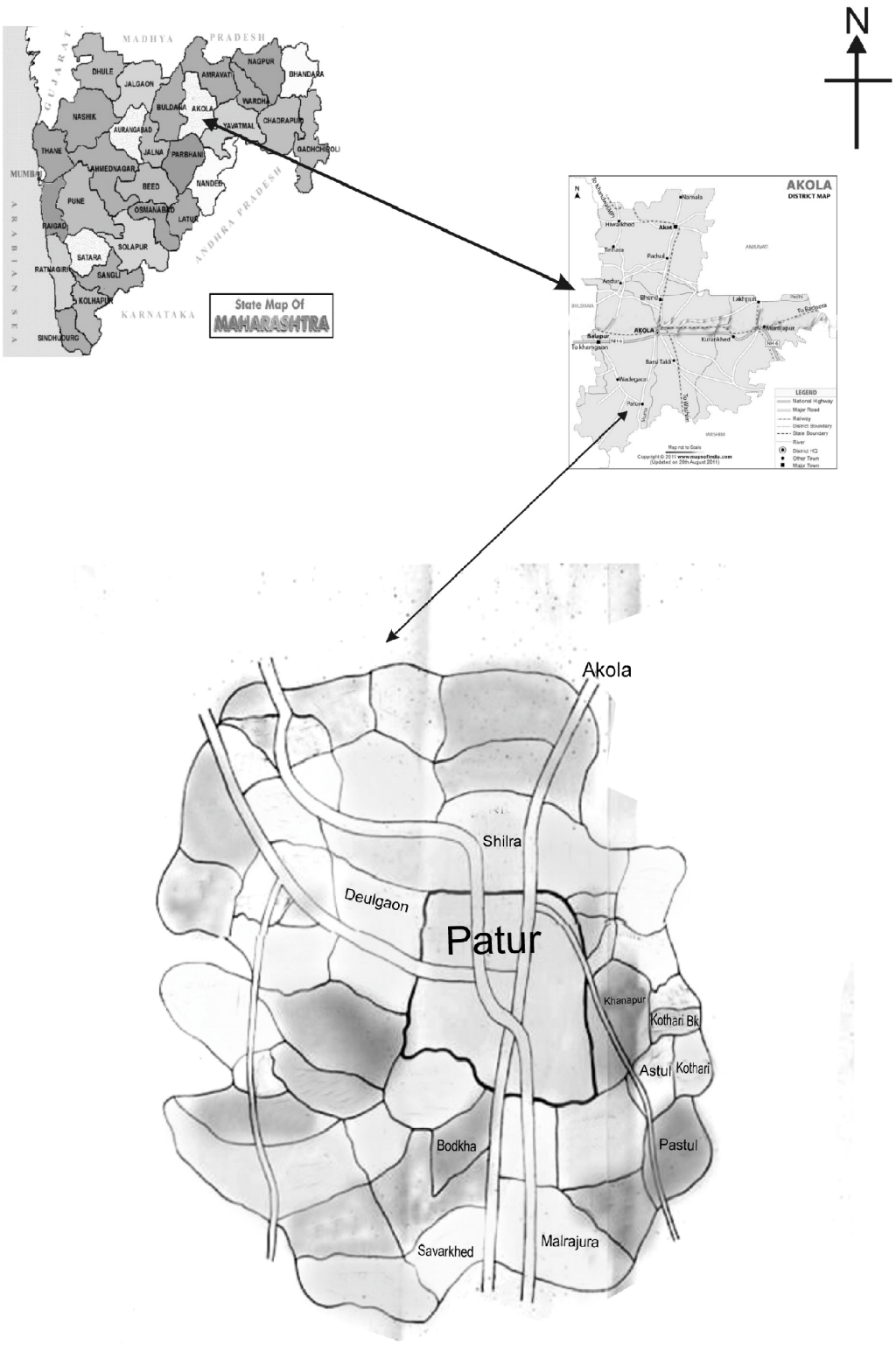

Fig. 1 : Map of Patur Tahsil

Table 2. Types of trees preferred by Farmers in Patur tehsil of Akola district of Maharashtra.

S.N.	Types of trees	Percent resoponse																					
		Aastul		Pastul		Kohari Kh		Kothari Bk		Khanpur		Shirla Andhare		Deulgaon		Bodkha		Malrajura		Sawarkhed		Average	
		R	I	R	I	R	I	R	I	R	I	R	I	R	I	R	I	R	I	R	I	R	I
1	Fuel wood yielding Species	100	_	100	_	100	_	100	_	100	_	90	10	100	_	100	_	100	_	100	_	99	1
2	Fruit yielding species	_	100	_	100	_	100	_	100	_	100	_	90	_	100	_	_	_	_	_	_	0	69
3	Fodder yielding species	_	_	20	_	_	_	20	_	20	_	40	_	_	_	90	_	100	_	70	_	36	0
4	Timber yielding Species	100	_	100	_	100	_	100	_	100	_	90	10	100	_	100	_	100	_	100	_	99	1
5	Multipurpose species	30	_	30	_	40	_	30	_	10	_	20	_	_	_	30	_	20	_	10	_	22	0
6	Short duration species	_		_		_		_		_		_		_		_		_		_		_	

R - Rainfed Agroecosystem I - Iriigated Agroecosystem

RESULTS AND DISCUSSION

The data pertaining to prominent agro forestry practices followed by farmers in Patur tahsil of Akola district are given in Table 1 and Fig 2. It was observed that, most of the farmers are practicing boundary planting (84%) under rainfed situation in selected villages followed bund planting (72%) in rainfed situation and agri-silviculture (66%) whereas few farmers are practicing agri –silvi-pastoral (11%) and scattered planting(1%). However in Irrigated situation the farmers are practicing horti-silviculture systems (69%) followed by Agri-silviculture systems (9%), agri-horti-silviculture system and block plantation (1%) each, Whereas Kitchen garden and Plantation along irrigation canal (27%) plantation near water sources (22%) .The data on type of trees species preferred by respondents is provided in Table 2 and Fig 3. As per the use of the trees and local needs preference of farmer for the trees are more preferred by farmers in the ten selected villages of Patur tahsil of Akola district of Maharashtra in rainfed and irrigated situations. 99% of the farmers in rainfed situation preferred the timber yielding species and fuel wood yielding species followed by fodder yielding species (36%) and multipurpose tree species (22%). Whereas 69% of the farmers in irrigated situation preferred the fruit yielding species followed by fuel wood yielding and timber yielding species (1%). Devaranavadgi *et al.* (2007) Conducted study at

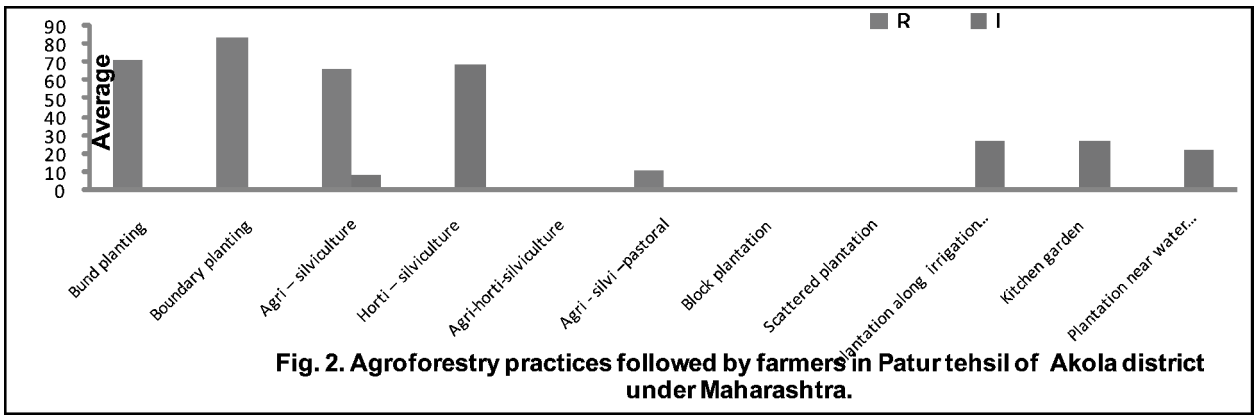

Fig. 2. Agroforestry practices followed by farmers in Patur tehsil of Akola district under Maharashtra.

Table 3: Major plant species found in different agroforestry systems.

S.N.	Scientific Name	Common/Local Name	Family	Uses/ Species
Tree Species				
1	*Tectona grandis*	Teak, Sag, Sagwan	*Meliaceae*	Timber, fuel wood, Calculus, Snake bite
2	*Azadirachta indica*	Neem, Kaduneem.	*Meliaceae*	Control store grain pest, Crop protection, Foods, Medicinal, Skin disease, Worm.
3.	*Terminalia bellerica*	Behada	*Combretaceae*	Non- Timber Forest Product, Timber, Fuel Wood,Fodder, Digestive, Cough, Diphtheria.
4.	*Dalbergia sissoo*	Sissoo	*Papillonaceae*	Timber.
5.	*Butea monosperma*	Palas	*Papillonaceae*	Timber, Fuel wood, Fodder, Scorpion bite, Worms.
6.	*Acacia catechu*	Khair	*Mimosaceae*	Timber, Fuel wood, Fodder.
7.	*Aegle marmelos*	Bael	*Rutaceae*	Medicinal, Fodder, Dysentry, Acidity.
8.	*Tamarindus Indica*	Tamarind , Chinch	*Caesalpiniaceae*	Timber, Scorpion bite.

9.	*Casuarina equisetifolia*	Saru	*Casuarinaceae*	Fuel wood
10.	*Emblica officinalis*	Aonla , Amla	*Eupoharbiaceae*	Digestive, Source vit –c
11.	*Acacia Arabica*	Babul	*Mimosaceae*	Strengthen of teeth and gums.
12.	*Semecarpus anacardium*	Marking nut/ Biba	*Anacardiaceae*	Medicinal – Asthma vit B. eating medicines, marking ink, godabi, protective color for ship.
Fruits species				
13	*Mangifera indica*	Mango	*Anacardiaceae*	Fruit, Fuel, Timber, Religious, Cash, (Medicinal- Diarrhoea, Dysentry)
14	*Citrus aurantifolia*	Limbu	*Rutaceae*	Fruit, Fuel , cash, (Medicinal – acidity)
15	*Musa paradisiaca*	Banana	*Musiaceae*	Fruit,Medicinal, cooking.
16	*Psydium guajava*	Guava	*Myrtaceae*	Fruit, Cash, (Medicinal-Fever, dysentery) Fuel wood
17	*Citrus reticulate*	Mandarin	*Rutaceae*	Fruit,fuel,Cash, Medicinal,Energy, Vitamin- c.
18	*Annona squamosa*	Custard apple	*Annonaceae*	Medicinal, Fruit, Fuel wood.
19	*Punica granatum*	Pomegranate	*Punicaceae*	Fruit, Medicinal.
20	*Zizyphus Mauritiana*	Ber	*Rhamanaceae*	Fruit ,Food, Fodder, Timber, Anaemia, Scorpion bite
Spices				
21.	*Allium cepa*	Onion	*Amaryllidacea*	Medicinal -Diabetes, cooking
22.	*Capsicum annuuam L.*	Chilli	*Solanaceae*	Cooking,
23.	*Curcurma longa L.*	Turmeric	*Zingiberaceae*	Cooking, Worms, Medicinal, Piles, Cough.
Agricultural crop				
24.	*Glysine max*	Soyabean	*Leguminaceae*	Medicinal, cooking, Cash
25.	*Gossypianur.spp*	Cotton	*Malvaceae*	Cash
26.	*Sorghum bicolor*	Jowar	*Poaceae*	Fodder, Cooking.
27.	*Cajanus cajan*	Tur	*Fobaceae*	Cooking,
28.	*Vigna radiate*	Mung	*Fabaceae*	Cooking
29.	*Triticum aestivum*	Wheat	*Poaceae*	Cash, Cooking
Vegetable				
30	*Solanum melongena*	Brinjal	*Solanaceae*	Cooking.
31.	*Spinacea oleracia*	Spinach	*Chenopodiaceae*	Medicinal , Cooking
32.	*Trigonella foenum graecum*	Fenugreek	*Leguminose*	Cooking, Food.
33.	*Corriandrum sativum*	Coriander	*Umbelliferae*	Cooking, Food.
34.	*Cucumis sativus*	Cucumber	*Cucurbitaceae*	Cooking, Food.
35.	*Moringo oleifera*	Drum stick	*Moringaceae*	Cooking, Food.
Grasses				
36.	*Pennisetum purpureum*	Napier	*Poaceae*	Fodder
37.	*Dichanthium annulatum*	Marvel	*Poaceae*	Fodder

Sources:- primary data collecting and agroforestry survey.

Karanataka to find out the prominent agroforestry practices and reported the different agroforestry followed by farmers in Karanataka. Whereas Saleem and Gupta (2007), Dhyani et al. (2009), Dwivedi et al. (2010) and Alao and Shuaibu (2011) worked on same parameters.

CONCLUSION

The study shows that agro forestry practices followed by farmers in Patur tahsil of Akola district are given in Table 1. was observed that, most of the farmers are practicing boundary planting 84% under rainfed situation in selected villages followed bund planting 72% in rainfed situation and agri-silviculture 66% whereas few farmers are practicing agri –silvi-pastoral 11% and scattered planting 1%. However in Irrigated situation the farmers are practicing horti-silviculture systems is 69%. The farmers in rainfed condition have long term objectives of low manufacture cost, therefore they preferred timber yielding as well as fuel wood species to fulfill the local needs where as farmers in irrigation situation have commercial aspect so preferred fruit trees which give maximum return in short duration period. 99% of the farmers in rainfed situation preferred the timber yielding species and fuel wood yielding species followed by fodder yielding species 36%.

It is observed that total 12 numbers of tree species, 08 numbers of fruit species, 03 numbers of spices, 06 numbers of agriculture crops, 06 numbers of vegetables and 2 numbers of grasses record in different agroforestry systems identified in study area.

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Variations in Physical Characteristics of Candidate Plus Trees of *Acacia nilotica* (L.) Willd

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ABSTRACT

Studies were conducted to investigate the candidate plus trees of *Acacia nilotica* for physical characteristics of sapwood. Significant differences were noticed for all the characters. The maximum height and diameter was observed in Lakhanwada-2 (19.27 m) and Ugwa-1(43.83 cm) whereas minimum height and diameter was observed in Vani-1(12.27 m) and Agar-2 (29.36 cm). Maximum deviation of grain i.e. 4.66^0 (85.34^0 against 90^0) with vertical axis was noticed in Lakhanwada-1, Vani-1 and Yeulkhed-1, respectively and minimum deviation of 1.33^0 (88.67^0 against 90^0) was recorded in Kapsi-1, Katepurna-2, Lakhanwada-2 and Vani-2, respectively. The maximum bark of 9.70 (3.11) per cent was noticed in Agar-1 and minimum of 2.98 (1.72) per cent in Mana-2. The highest specific gravity of sapwood (0.7622) was recorded in Ugwa-1 and lowest specific gravity (0.6730) was observed in Kapsi-2. Maximum length of fiber was noticed in Mana-2 (1.57 mm) and minimum was recorded in Sangdlud-2 (1.33 mm). From this study it could be concluded that substantial amount of variation was observed for all the physical characteristics of sapwood of *Acacia nilotica* marked at different locations in Akola district of Maharashtra.

The potential of *Acacia nilotica* as a multipurpose tree has been recognized worldwide. This species is found in tropical and sub-tropical Africa and Asia. In India, it is located throughout dry and hot regions ranging from 9^0N to 34^0N latitude and 72^0E to 92^0E longitude, and ascending to an altitude of 900m. It withstands an absolute maximum temperature of 50ÚC, minimum temperature of -5^0C and can be supported by an annual rainfall of 75 to 1,300 mm. *Acacia nilotica* is a tree 5-20 m high with a dense spherical crown, stems and branches usually dark to black coloured, fissured bark, grey-pinkish slash, exuding a reddish low quality gum. (Arya and Toky, 2006).

A nilotica is naturally widespread in the drier areas of Africa, from Senegal to Egypt and down to South Africa, and in Asia from Arabia eastward to India, Burma and Sri Lanka. The largest tracts are found in Sind. It is distributed throughout the greater part of India in forest areas, roadsides, farm lands, agricultural fields, village grazing lands, wastelands, bunds, along the national highways and railways lines. Mostly it occurs as an isolated tree and rarely found in patches to a limited extent in forests. The occurrence of this species over a wide geographic range encompassing a great diversity of edaphoclimatic conditions of its habitat, is expected to be reflected in the genetic constitution of its diverse populations. The species therefore, often an opportunity for studying variation and to select the superior trees for adaptability and growth.

The purpose of candidate plus tree testing is to estimate the probability that only better gene or population can be found for at least one trait which can be used to improve the productivity of planting programme. Studies on variation in physical traits of candidate plus trees and selection of the best performing CPTs in a particular climatic condition assume great importance. The present paper deals with the observations made on the variation in height, diameter, grain angle, bark percentage, specific gravity of sap wood and fiber length of twenty CPTs of *Acacia nilotica* marked at different locations in Akola district of Maharashtra.

MATERIAL AND METHODS

The present investigation was carried out in Akola district of Maharashtra and total twenty trees were marked at different locations. The morphological parameters of these marked trees were taken at site and the wood samples were chipped at breast height with the help of hammer and chisel for the evaluation of specific gravity of sapwood and fiber length. Laboratory analysis of the collected sample was done in the Department of Forestry, Dr. PDKV, Akola (MS).

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The height of each tree was measured with the help of Ravi altimeter. The readings were taken from two different locations from where the top and base of the trees were visible. The average of these readings was recorded as the height of the tree in meters. Diameter of trees was measured at breast height (1.37 m from the ground level) with the help of tree caliper. It was measured at two points which were at right angle to each other and mean value of these two observations was recorded as diameter at breast height in cm. Grain angle of the trees were measured by drawing straight line perpendicular to the base of tree trunk and the deviation of the grain was measured with the help of protractor after shaving the bark. Bark thickness of the trees was measured by Swedish bark gauge at site. It was measured at four locations perpendicular to each other at breast height and the average of these were taken as bark thickness. The recorded bark thickness was expressed as percentage. The specific gravity of sapwood was determined by the maximum moisture method (Smith, 1954). Fiber length was determined by macerating the shavings of wood in Jeffery's fluid, i.e. 10 per cent chromic acid and 10 per cent nitric acid for 48 hours (Pandey *et al.*, 1968). There were 20 treatments and three replications for each treatment. The statistical analysis for each character was carried out as mean values. The data was analyzed by using the randomized block design as described by Panse and Sukhatme (1978) and Chandel (1984).

RESULTS AND DISCUSSION

The data pertaining to the height and diameter of CPTs of *Acacia nilotica* is presented in Table 1. Perusal of data revealed significant variation in height and the mean height ranged from 19.27m to 12.27m. The maximum

Table 1. Physical parameters of candidate plus trees of *Acacia nilotica* marked at different locations in Akola District.

S. N.	Locality	Tree No.	Height (m)	Diameter (cm)	Grain angle (deviation) in degrees
1	Aagar	A-1	16.43	30.23	88.00(2.00)
2	Aagar	A-2	18.13	29.36	88.34(1.66)
3	Kapsi	K-1	13.13	29.6	88.67(1.33)
4	Kapsi	K-2	14.57	42.13	87.34(2.66)
5	Katepurna	Kt-1	15.27	38.46	87.34(2.66)
6	Katepurna	Kt-2	15.27	41.23	88.67(1.33)
7	Lakhanwada	L-1	16.7	36.93	85.34(4.66)
8	Lakhanwada	L-2	19.27	34.23	88.67(1.33)
9	Mana	M-1	13.47	36.6	88.34(1.66)
10	Mana	M-2	12.3	33.53	86.34(3.66)
11	Patur	P-1	13.23	31.26	86.34(3.66)
12	Patur	P-2	16.23	38.74	86.34(3.66)
13	Sangdlud	S-1	14.7	34.6	86.67(3.66)
14	Sangdlud	S-2	15.3	36.54	87.34(2.66)
15	Ugwa	U-1	12.6	43.83	87.67(2.33)
16	Ugwa	U-2	17.33	30.26	87.34(2.66)
17	Vani	V-1	12.27	40.74	85.34(4.66)
18	Vani	V-2	13.3	35.56	88.67(1.33)
19	Yeulkhed	Y-1	15.47	37.83	85.34(4.66)
20	Yeulkhed	Y-2	16.8	37.34	87.34(2.66)
		Mean	15.09	35.95	88.27(2.73)
		SE (d)	0.1032	0.1653	SE(m)=0.309
		CD(0.05)	-	-	0.576

Table 2. Bark percentage, specific gravity and fiber length of sapwood of candidate plus trees of *Acacia nilotica* marked at different locations in Akola District.

S. N.	Locality	Tree No.	Bark Percentage (%)	Specific gravity	Fiber length (mm)
1	Agar	A-1	9.70(3.11)	0.7247	1.45
2	Agar	A-2	9.30(3.05)	0.7320	1.41
3	Kapsi	K-1	7.65(2.77)	0.7016	1.43
4	Kapsi	K-2	4.91(2.21)	0.6730	1.38
5	Katepurna	Kt-1	6.93(2.63)	0.7572	1.53
6	Katepurna	Kt-2	4.20(2.05)	0.7378	1.50
7	Lakhanwada	L-1	4.51(2.12)	0.7258	1.39
8	Lakhanwada	L-2	8.57(2.93)	0.7466	1.35
9	Mana	M-1	7.47(2.73)	0.7014	1.46
10	Mana	M-2	2.98(1.72)	0.7425	1.57
11	Patur	P-1	8.68(2.95)	0.6757	1.41
12	Patur	P-2	4.82(2.19)	0.7575	1.53
13	Sangdlud	S-1	9.06(3.01)	0.7150	1.51
14	Sangdlud	S-2	8.76(2.96)	0.7468	1.33
15	Ugwa	U-1	6.46(2.54)	0.7622	1.45
16	Ugwa	U-2	5.73(2.39)	0.7520	1.53
17	Vani	V-1	7.86(2.80)	0.7515	1.56
18	Vani	V-2	3.56(1.88)	0.7578	1.48
19	Yeulkhed	Y-1	3.49(1.87)	0.6877	1.40
20	Yeulkhed	Y-2	6.96(2.64)	0.7615	1.52
		Mean	6.58(2.53)	0.7305	1.46
		SE (m)	0.058	0.0140	0.038
		CD(0.05)	0.109	0.0261	0.071

*Figures in parenthesis are square root transformed value

height 19.27m recorded in Lakhanwada-2. The minimum height of 12.27m was observed in Vani-1 which was statistically at par with Mana-2, Ugwa-1 Patur-1, Mana-1, Kapsi-1 and Vani-2. The CPT's also recorded significant variation in diameter. The mean diameter ranged from 29.36 cm to 43.83 cm and the maximum value of 43.83 cm was observed in Ugwa-1 whereas the minimum diameter of 29.36cm was recorded in Agar-2. This variation could be attributed to the genetic constitution, environment and the interaction with the microsite of marked CPT's. The data of CPTs recorded significant variation in grain angle (Table 1). The minimum deviation of 1.33° (88.67 against 90°) with vertical axis was recorded in Kapsi-1, Katepurna-2, Lakhanwada-2 and Vani-2 respectively. The maximum deviation of grain i.e. 4.66° (85.34° against 90°) was observed in Lakhanwada-1, Vani-1 and Yeulkhed-1, respectively.

The data on bark percentage, specific gravity and fiber length are presented in Table 2. The scrutiny of data revealed the significant variation in bark percentage. The maximum bark percentage of 9.70 (3.11) per cent was found in Agar-1 and minimum of 2.98 (1.72) per cent was recorded in Mana-2. Toda et al. (1994) have reported variation of bark thickness and fissures varied with tree age. This parameter is dependent upon the age of the tree, hence there was variability for bark percentage in the marked CPTs. The data related to the specific gravity of sapwood revealed significant variation among the CPTs of *Acacia nilotica*. The maximum specific gravity of 0.7622 was noticed in Ugwa-1 and minimum specific gravity of 0.6730 was recorded in Kapsi-2. Extractives are located mainly in the lumen, so they fill the vacant spaces in the wood, decreasing the porosity and thereby increasing the specific gravity. This variation is due to

the varied accumulation of phenol and other extractives. Specific gravity is often taken as an indicator of wood quality (Panshin and DeZeeuw, 1970). Variation in specific gravity of wood has been reported by Okkonen et al. (1972) and Zobal and Talbert (1984).

The data on fiber length exhibited significant variation in fiber length in different CPTs. The maximum length of fibers was noticed in Mana-2 (1.57 mm) and minimum length of fibers (1.33 mm) was obtained in Sangdlud-2. Mutibaric (1968) have reported that the fiber length is genetically controlled and is not under the influence of environment fluctuations. But environment in combination with genetic variability also plays an important role in the alteration of fiber length as has been reported by Boyce and Kaeiser (1969). Jiang Xiaomei *et al.* (1994) also observed significant variation in fiber length of *Populus deltoides*. Stinger and Olson (1987) found significant statistical difference among sampling heights in fiber length, ash content and heartwood content in *Robinia pseudoacacia*.

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Adoption Status of Pesticides as Per the Label Claims by the Cotton Growers in *Vidarbha*

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ABSTRACT

A systematic survey of 150 soybean growers was conducted in Akola, Buldana, Washim, Amravati, and Yavatmal districts of Vidarbha during 2015-16 as University Research Review Committee Project. The main objective of the study was to study the knowledge level of the selected cotton growers, extension functionaries and proprietor of Krushi Seva Kendras about the pesticides label claims. The key finding revealed that in selected five district of Vidarbha out of 150 selected cotton farmers 145 (96.67%) and 62.50 per cent selected extension workers were observed in low knowledge level group about the pesticides label claims. This study also clears that majority 77.50 per cent proprietors of Krushi Seva Kendras have high level knowledge about the label claim of pesticides. But it was noted that they were not using these knowledge for promoting the uses of pesticides having label claims of CIB & RC among the farming community. They ignored the CIB & RC recommendations while selling the pesticides to farmers. The results regarding the adoption status of pesticides revealed that large number of the selected farmers using herbicides, insecticides and fungicides without label claim (Which is not approved by CIB&RC). That means these pesticides were registered for other crops by CIB&RC, but farmers using these for cotton crop. Hence this study clears that there is a need to create the awareness among the farming community and extension functionaries about the label claims of pesticides. It will help to improve the adoption status of pesticides having label claim for specific crop and specific purpose approved by the CIB&RC. It will also help to make uniformity in the recommendations made by the Central Insecticide Board and all other government institutions for betterment of farming community. Secondly it will also help to either set the MRLs of a pesticide for appropriate food commodities or to monitor pesticide residues for food safety.

Many of the farmers recently using the pesticides including herbicides, insecticides, and fungicides in all major field crops in India. Pesticide labels contain detailed information on how to use the product correctly and legally. Pesticide use in India is regulated by the Central Insecticides Board and Registration Committee (CIB & RC) and the Food Safety and Standards Authority of India (FSSAI). The CIB & RC registers pesticides for crops while the FSSAI sets the maximum residue limits (MRL) of pesticides for the crops it has been registered for Anonymous (2013). If a food has a higher level of residue than the MRL, it does not automatically mean that the food is not safe to eat. A residue above the MRL may show that the farmer has not used the pesticide properly (Anonymous, 2010[b]). Uses of spurious and non-recommended pesticides by the Central Insecticides Board and Registration Committee i.e. without approved label claims are the reasons of pesticide residues in food commodities (Sharma, 2013).

The use of pesticides is a hazardous sector and unless pesticides are used as approved by the Registration Committee, the whole environment could be at risk. There have been issues country-wide about the inadequate knowledge about the label claims and their utilization. About 90 per cent of usage of pesticides is without approved label claims. These lead to presence of residues of those pesticides, which are not approved for use on particular crops. State Governments should ensure that the molecule recommended for use on one commodity and banned on another should not juxtapose each other. Much of problems, which are faced today are due to lack of awareness, lack of sensitivity and lack of seriousness to be implementing what should be actually implemented. He emphasized that if the pesticides are used sensibly, they are the most opportune system for increasing productivity, Anonymous (2010[a]).

Recently non availability of labourers coupled with more cost is a very severe problem with the majority of the farmers (Kale, *et.al*, 2011 and Kale, *et.al,* 2013). Under such situation post-emergence herbicides remain the only viable option for an effective and economical method of weed control (Kumar *et al*., 2003, Jha *et al*., 2014, Dhaker, *et al*. 2015 and Nandini Devi et al., 2016). Secondly maximum number of farmers using various insecticides and fungicides in cotton crop in Vidarbha. Pesticide Companies registered its products as per the Insecticide

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Act 1968 and claimed that the registered products are for management of certain weed/ pest/disease in particular crop(s) only as per the written, printed or graphic label on the container approved by the government regulatory agencies i.e. Central Insecticides Board & Registration Committee (CIB&RC). When the farmers using the pesticides as per the crops specified on label approved by the CIBRC, then we can say that farmers using the pesticides as per the label claim. But it was observed that farmers were unaware about the pesticides label claims and they mostly using the agricultural pesticides as the input dealers recommended them. Hence this becomes a researchable issue for the researchers. Hence this research study was planned with the main objective to study the knowledge level of the selected cotton farmers about the pesticides label claims and to investigate the adoption status of the pesticides as per the label claims by the cotton growers in Vidarbha .

MATERIAL AND METHODS

The present investigation was carried out in Akola, Buldana, Washim, Amravati, and Yavatmal districts of Vidarbha region of Maharashtra by using the exploratory design of social research with multistage sampling method. From each district one Tahsil is selected were cotton crop cultivated by the majority farmers during 2015-16. From each selected tahsil 3 villages were selected randomly and from each selected village 10 farmers were interviewed with the help of structured interview schedule. Thus this investigation was confined to a sample of 150 farmers having cotton crops during the year 2015-16. A teacher made knowledge test was developed to measure the knowledge of an individual respondents about the label claims of pesticides, responses of the respondents were taken on two point continuum i.e. yes/no and numerical score of 1 and 0 was assigned respectively. Obtained knowledge raw score was converted into knowledge index by using following formula.

$$\text{Knowledge index (\%)} = \frac{\text{Knowledge score actually obtained}}{\text{Maximum obtainable knowledge score}} \times 100$$

The respondents were categorized according to obtained knowledge index score with equal interval method as low (Upto 33.33), medium (33.34 to 66.66) and high (Above 66.66) level of knowledge regarding pesticides label claims.

While studying the adoption status of pesticides researchers have consider the list of pesticides registered under the Insecticides Act, 1968 for cotton crops up to 31.08.2015 including herbicides, insecticides and fungicides by the Central Insecticides Board & Registration Committee, Government of India, Ministry of Agriculture Department of Agriculture & Cooperation, Directorate of Plant Protection, Quarantine & Storage, Faridabad Anonymous (2016). For studying the adoption status of pesticides as per label claims researchers had investigate the pesticides which have been used by the cotton growers those are registered by CIBRC for cotton and those have not registered for cotton crops even though farmers had used for cotton crop.

Table 1 : Distribution of the selected farmers according to knowledge about the pesticides label claims

S.N.	Knowledge test statements about the pesticides label claims	Knowledge (N=150)	
		Yes	No
1	Do you know about insecticide act 1968 ?	5 (3.33)	145 (97.00)
2	Do you know about the central insecticide Board and Registration Committee (CIB&RC)?	5 (3.33)	145 (97.00)
3	Do you know what the pesticides label claims is ?	5 (3.33)	145 (97.00)
4	While purchasing the pesticide do you ensure whether it is having label claim for the pest/weed you want to control	5 (3.33)	145 (97.00)
5	Prior to spraying of pesticides do you read the instructions given on the label of pesticides?	5 (3.33)	145 (97.00)
6	While spraying pesticide do you spray as per the label claim dosages and against particular crop pest?	5 (3.33)	145 (97.00)
7	Do you know the pesticides doses should be mixed thoroughly in prescribed quantity of water as per label claim?	9 (6.00)	141 (94.00)
8	Do you know the waiting period of pesticide?	9 (6.00)	141 (94.00)

RESULTS AND DISCUSSION

Knowledge of selected farmers about the pesticide label claims

Total 8 important statements about the pesticides label claims have been considered for accessing the knowledge of selected farmers about the label claims. The results regarding the knowledge of the selected respondents about the pesticides label claims have been presented in Table 1.

It was observed from Table 1, that majority (97.00%) of the selected farmers were found to be unaware about Central Insecticide act 1968, Central insecticide Board and Registration Committee (CIB&RC), what the label claim of pesticides is and whether pesticides having label claim for the particular pest/disease/weed for particular crop. Whereas, 94.00 per cent farmers have no knowledge about the doses of pesticides, quantity of water to be use for mixing the pesticide, waiting period of pesticides is given on the label of the pesticides container and their importance with seriousness.

Overall knowledge level of the selected farmers

Overall knowledge level of selected farmers about selected eight statements about the pesticides label claims has been computed in the form of index and respondents have been distributed in three categories by equal distribution method as given in Table 2.

Table 2. Distribution of the respondents according to their level of knowledge about the pesticides label claims

S.N.	Knowledge level	Respondents	Percentage
1	Low (Upto 33.33)	145	96.67
2	Medium (33.34 to 66.66)	0	00.00
3	High (Above 66.67)	05	3.33
	Total	**150**	**100.00**

It was observed from the data depicted in Table 2 that majority 96.67 per cent selected farmers were found in low knowledge level group, this group of farmers have heard the world label claims of pesticides first time during the interview by the researcher and only 3.33 per cent respondents have high level of knowledge about the pesticides label claims. These groups of farmers were having either input shop or close contact with the input dealers. Hence have knowledge about the pesticides label claims.

Knowledge level of Extension functionaries about the pesticides label claims

In addition to the farmers of study area researchers have taken the representative sample of 40 Extension functionaries from the selected districts and tested their knowledge about the label claims of pesticides. The data regarding the educational level of the selected extension functionaries and their knowledge about the pesticides label claims are presented in Table 3 and 4 as follows.

Table 3: Distribution of the selected Extension functionaries according to their educational level

S.N.	Educational level	Frequency	Percentage
1.	Agril. Diploma	23	57.50
2.	B.Sc. (Agri)/M.Sc.(Agri)	17	42.50
	Total	40	100.00

It was observed from Table 3, that all selected extension functionaries were learned persons, out of the selected 57.50 per cent were Agricultural Diploma holders and remaining 42.50 per cent were agricultural graduates and post graduates.

Table 4: Distribution of the selected Extension functionaries according to Knowledge about the pesticides label claims

S.N.	Knowledge test statements about the pesticides label claims	Knowledge (N=40)	
		Yes	No
1	Do you know about the insecticide act 1968?	14 (35.00)	26(65.00)
2	Do you know about the Central Insecticide Board and Registration Committee (CIB&RC)?	11 (27.50)	29(72.50)
3	Do you know what the pesticides label claims are?	22 (55.00)	18(45.00)
4	Do you know prior to giving advice to the farmers every extension personnel have to read the label of pesticides and give advice as per the label claims?	21 (52.50)	19(47.50)
5.	Do you have knowledge about the waiting period of pesticides?	18 (45.00)	22(55.00)

The results regarding the knowledge of the Extension functionaries about the pesticides label claims clears from Table 4, that 72.50 per cent extension workers of the state department of agriculture do not aware about the CIB and RC, followed by 65.00 per cent extension workers do not know about the insecticides act 1968. Whereas 55.00 per cent extension workers have awareness knowledge about the label claims of pesticides. Knowledge about to read the pesticides label before advice to the farmers and 45.00 per cent extension functionaries know about the waiting period of pesticides in study area. The Overall knowledge level of selected extension functionaries about selected five statements about the label claims of pesticides has been computed in the form of index and respondents has been distributed in three categories by equal distribution method as given in Table 5.

Table 5. Distribution of the selected extension functionaries according to their overall knowledge level about pesticides label claims.

S.N.	Knowledge level	Respondents	Percentage
1	Low (Upto 33.33)	25	62.50
2	Medium (33.34 to 66.66)	08	20.00
3	High (Above 66.66)	07	17.50
	Total	**40**	**100.00**

It was observed form Table 5, that 62.50 per cent selected extension functionaries were observed in low level of overall knowledge about the selected five statements of pesticides label claims. It was followed by 20.00 per cent falls in medium category and remaining 17.50 per cent observed in high knowledge level about the label claims of pesticides. Hence this study clears that awareness knowledge of the extension functionaries should have to be enhanced through the training programmes by the State Department of Agriculture and KVKs.

Knowledge level of Proprietors of *Krushi Seva Kendras*

In addition to the farmers and Extension functionaries of study area researchers have taken the representative sample of 40 input dealers from the selected districts and tested their knowledge about the label claims of pesticides. The data regarding this have been presented in Table 6 as follows.

Table 6: Distribution of the selected Proprietors of *Krushi Seva Kendra* according to knowledge about pesticides label claims

S.N.	Knowledge test statements about the Label claim	Knowledge (N=40) Yes	No
1	Do you know about insecticide act 1968 ?	31(77.50)	09(22.50)
2	Do you know about the central insecticide Board & Registration Committee ?	27 (67.50)	13 (32.50)
3	Do you know what the pesticides label claims are?	37 (92.50)	03 (07.50)
4	Do you know prior to selling of pesticides you have read the instructions given on the label of pesticides?	37 (92.50)	03 (07.50)
5	Do you know while selling the pesticide you has to ensure whether is having label claim for the specific purpose and for specific crop.	38 (95.00)	02 (05.00)
6	Do you know while recommending pesticide dosages you have to give the advice to the farmers as per the dosages mentioned on label claim?	37 (92.50)	03 (07.50)

Knowledge of Proprietors of *Krushi Seva Kendras* about the label claim of pesticides have been studied and the results were depicted in Table 6, clears that majority of the input dealers (Proprietors of *Krushi Seva Kendras*) have knowledge about the label claims statements constructed by the researchers. The overall knowledge has been also computed in the form of knowledge index and results are presented in Table 7 as follows.

Table 7. Distribution of the selected Proprietors of Krushi Seva Kendra according to their level of knowledge about pesticides label claims.

S.N.	Knowledge level	Respondents	Percentage
1	Low (Upto 33.33)	02	5.00
2	Medium (33.34 to 66.66)	07	17.50
3	High (Above 66.67)	31	77.50
	Total	**40**	**100.00**

It was clears from the results depicted in Table 7, that majority 77.50 per cent proprietors of *Krushi Seva Kendras* have knowledge about the pesticides label claims, followed by 17.50 per cent have medium level of knowledge and remaining 5.00 per cent falls in low level category of knowledge about the pesticides label claims in study area. But it was noted that they were not using these knowledge for promoting the uses of pesticides having label claims of CIB & RC among the farming community. They ignored the CIB & RC recommendations while selling the pesticides to farmers. These may lead to presence of residues of those pesticides, which are not approved for use on particular crops.

Adoption status of herbicides as per the label claims

Herbicide use frequency of selected Cotton growers during 2015-16 have been studied and the results regarding the herbicide use frequency and herbicide adoption status as per label claims and not as per label claims by the Cotton growers have been presented in Table 8 and 9, respectively as follows.

Table 8: Distribution of the cotton growers according to the herbicide use frequency

S.N.	Herbicide use frequency	Respondents	Percentage
1	Not applied	112	**74.67**
2	Once in crop duration	31	20.67
3	Twice in crop duration	7	4.66
	Total	**150**	**100.00**

It was observed from Table 8 that majority 74.67 per cent cotton growers have not used the herbicides in cotton crop. This might be due to lack of monsoon rains after planting of cotton crop. In Vidarbhs region of Maharashtra there was frequent long gaps after planting the cotton crops during 2015-16. Hence due to not availability of sufficient moisture in soil farmers have not applied the herbicides. During 2013-14 Dr.PDKV, Akola has conducted one research study on adoption of herbicides by the cotton crop in the same area of Vidarbha and observed that 48.17 per cent have applied the herbicides during 2013-14 in cotton crop (Kale, *et al.* 2014).

Herbicides registered for cotton by CIBRC and used by the selected cotton growers along with herbicides not registered for cotton by CIBRC and used by the selected cotton growers have been depicted in Table 9 as bellow.

Glyphosate 41% SL IPA Salt and Propaquizafop 10% EC have registered for other crops by CIBRC, but farmers have used them in cotton crop in Amravati revenue division of Vidarbha.

Adoption status of insecticides

Insecticides use frequency of selected Cotton growers during 2015-16 have been studied and the results regarding the insecticides use frequency and insecticides adoption status as per label claims and not as per label claims by the Cotton growers have been presented in Table 10 and 11, respectively as follows.

Table 9 : Herbicide adoption status as per label claims by the Cotton growers

S.N.	Herbicides used as per label claims	No of farmers N= 38	% over adopters	
1	Pendimethalin 30% EC	5	13.16	
2	Pyrithiobac Sodium 10% EC	2	5.26	
3	Quizalofop-ethyl 5% EC	2	5.26	
S.N.	**Herbicides used but not registered for cotton by CIBRC**	**No of farmers N= 38**	**% over adopters**	**Registered for crops**
1	Glyphosate 41% SL IPA Salt	27	71.05	Tea& Non-cropped area
2	Propaquizafop 10% EC	9	23.68	Soybean, Blackgram & Onion

Table 10. Distribution of the cotton growers according to the insecticides use frequency

S.N.	Insecticides use frequency	Respondents	Percentage
1	1 to 2 Sprays	14	9.34
2	3 to 4 Sprays	66	44.00
3	5 to 6 Sprays	59	39.33
4	7 to 8 Sprays	8	5.33
5	Not applied	3	2.00
	Total	**150**	**100.00**

Results' regarding insecticides use frequency of cotton growers during 2015-16 clears that 98.00 per cent cotton growers have used the insecticides for cotton crop. Majority (83.33%) cotton farmers have applied 3 to 6 sprays of insecticides in study area even though all selected respondents have Bt cotton varieties.

Insecticides used but not registered for cotton by CIB&RC are Dimethoate 30% EC used by 13.38 per cent cotton farmers, followed by Buprofezin 15 per cent + Acephate 35 per cent WP (7.75%) and Betacyfluthrin 8.49 per cent + Imidacloprid 19.81per cent OD (2.11%).

Table 11: Insecticides adoption status as per label claim by the Cotton growers

S.N.	Insecticides used as per label claims	No of farmersN=142	% over adopters
1	Imadacloprid 17.8%SL	110	77.46
2	Monocrotophos 36%SL	70	49.30
3	Acephate 75%SP	69	48.59
4	Acetamiprid 20%SP	55	38.73
5	Imidacloprid 70 % WG	35	24.65
6	Fipronil 5%SC	29	20.42
7	Flonicamid50%WG	25	17.61
8	Lamda-cyclothin 5%EC	24	16.90
9	Acephate50%+Imidacloprid1.8%SP	22	15.49
10	Diafenthiuron 50%WP	21	14.79
11	Profenofos40%+Cypermethrin4%EC	18	12.68
12	Imadacloprid 30.5% m/m SC	17	11.97
13	Emamectin Benzoate5%SG	16	11.27
14	Thimethoxam 25 WG	14	9.86
15	Trizophos 40%	13	9.15
16	Deltamethrin1%+ Trizophos 35%EC	8	5.63
17	Flubendiamide20% WG	7	4.93
18	Azadirachtin 0.03% 300 PPM	7	4.93
19	Profenofos 50%EC	5	3.52
20	Dinotefuran 20% SG	3	2.11
21	Chlorpyrifos20%EC	2	1.41
22	Flubendiamide 39.35% M/M SC	2	1.41
23	Chlorantraniliprole	2	1.41
24	Quinalphos 20 % AF	1	0.70

S.N.	Insecticides used but not as per label claim	No of farmers of CIB&RC	%	Registered for crops
1	Dimethoate 30%EC	19	13.38	Bajra, Maize, Sorghum, Bhindi, Brinjal, Cabbage & Cauliflower, Chillies, Onion, Potato ,Tomato, Apple, Apricot, Banana, Citrus, Fig, Mango and Rose
2	Buprofezin 15% + Acephate 35%WP	11	7.75	Paddy
3	Betacyfluthrin 8.49% + Imidacloprid 19.81% OD	3	2.11	Brinjal

Adoption status of fungicides

Fungicides use frequency of selected Cotton growers during 2015-16 have been studied and the results regarding the fungicides use frequency and fungicides adoption status as per label claims and not as per label claims by the Cotton growers have been presented in Table 12 and 13 respectively as follows.

Table 12. Distribution of the cotton growers according to the fungicides use frequency

S.N.	Fungicides use frequency	Respondents	Percentage
1	1 Sprays	42	28.00
2	2 Sprays	25	16.67
3	3 Sprays	21	14.00
4	4 Sprays	8	5.33
5	Not applied	54	36.00
	Total	**150**	**100.00**

Results' regarding fungicides use frequency of cotton growers during 2015-16 clears that more than three fourth (36.00%) per cent cotton growers have not used any fungicides for cotton crop. More than one fourth (28.00%) per cent farmers have taken one spray of fungicides during crop period, followed by 2 spray (16.67%) and 3 spray (14.00%) and remaining 5.33 per cent farmers have applied 4 sprays of fungicides in cotton crop in combination with insecticides. Fungicides registered for cotton by CIB&RC and used by the selected cotton growers along with fungicides not registered for cotton by CIB&RC and used by the selected cotton growers have been depicted in Table 13 as below.

It was observed from Table 13 that there are 8 fungicides which were not registered by CIBRC for cotton crop but cotton growers using them. This should have to be control by the government agencies.

Table 13: Fungicides adoption status as per label claim by the Cotton growers

S.N.	Fungicides used as per label claim	No of farmers N=96	% Over adoptors	
1	Carbandezim 50%WP	37	38.54	
2	Pyraclostrobin 20%WG (Head Line)	33	34.38	
3	Sulpher 40% WP	4	4.17	
S.N.	**Fungicides used but not registered for cotton crop**	**No of farmers N=96**	**% Over adoptors**	**Registered for crops**
1	Carbendazim 12%+ Mancozeb 63 % WP (Saaf/Sprint)	51	53.13	Groundnut, Paddy, Potato, Tea, Grape & Mango
2	Tebuconazole 50 % + Trifloxystrobin 25 % WG (Nativo)	32	33.33	Rice & Tomato
3	Propiconazole 25%EC (Tilt)	15	15.63	Wheat, Rice, Groundnut, Tea, Sayabean
4	Propineb 70 WP	11	11.46	Apple, Pomegranate,Potato, Chilli, Tomato, Grapes, Rice
5	Thiophanate methyl 70%WP	10	10.42	Papaya, Apple, Tomato,Bottle gourd, Grapes
6	Hexaconazole 5%SC	8	8.33	Apple, Rice, Groundnut,Mango, Soybean, Tea,Grapes
7	Hexaconazole 4%+Zineb 68%WP	3	3.13	Paddy & Tea
8	Captan70%+ Hxaconazole 5%WP	2	2.08	Chillies & Potato

- Common name of fungicides in brackets

Problems/ constraints expressed by the selected farmers

Information about the problems faced by the farmers in use of pesticides as per the label claims has been identified and are depicted in Table 14.

Table 14: Problems/ Constraints perceived by the selected farmers about use of pesticides as per label claims.

S.N.	Problems/ Constraints	No	%
1	Lack of awareness about label claim	140	93.33
2	Lack of awareness about the benefits and adverse effects of using pesticides as per label claim	60	40.00
3	Label is not readable	59	39.33

It was clears from Table 14, that lack of awareness about label claims of pesticides amongst the farming community is the major problems with 93.33 per cent selected farmers in study area, followed by lack of awareness about the benefits and adverse effects of using pesticides as per label claim is mentioned by 40.00 per cent farmers. Label is pasted on the container is not readable is the constraints expressed by 39.33 per cent farmers. All these constraints should have to be rectified by the CIB&RC and State regularity functionaries. It will definitely help for promoting the approved uses of pesticides by CIB&RC in the all States of India.

CONCLUSION

In selected five district of Vidarbha 96.67 per cent farmers and 62.50 per cent selected extension workers were observed in low knowledge level group about the pesticides label claims. Whereas, majority (77.50%) proprietors of *Krushi Seva Kendras* have high level knowledge about the label claim of pesticides, but they are not using these knowledge for promoting the uses of pesticides having label claims of CIB & RC among the farming community. They ignored the CIB & RC recommendations while selling the pesticides to farmers. The results regarding the adoption status of pesticides revealed that large number of the selected farmers has used the herbicides, insecticides and fungicides without label claim (Have not approved by CIB&RC). That means these pesticides were registered for other crops by CIB&RC, but farmers using these for cotton crop. Hence this study clears that there is a need to create the awareness knowledge among the farming community and extension functionaries about the pesticide label claims. Similarly make mandatory to all input dealers to sale the pesticides as per the pesticides label claims. It will help to improve the adoption status of pesticides having label claim for specific crop and specific purpose approved by the CIB & RC and it will also help to make uniformity in the recommendations made by the Central Insecticide Board and all other government institutions for betterment of farming community. Secondly it will also help to either set the MRLs of a pesticide for appropriate food commodities or to monitor pesticide residues for food safety.

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Effect of Formaldehyde Treated Concentrate, Urea and Soybean Meal on Serum Total Protein and Serum Total Urea of Lactating Cows

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ABSTRACT

Present investigation entitled "Effect of Formaldehyde Treated Concentrate, Urea and Soybean Meal on Serum total protein and Serum total urea of lactating cows" was undertaken at Department of Animal Husbandry and Dairy Science, Dr. PDKV, Akola. Feeding of 1.5 per cent formaldehyde treated 70:30 sugras : SBM concentrate mixture with 2 per cent added urea diet to lactating cows (T_3) was evaluated in relation to sugras untreated ration (T_1). The results on metabolic blood profile of cows in reference to serum total protein (STP) and blood urea (BU) contents, it was observed that the levels of these two parameters were found within the normal range of 6 g/dl and 12 to 58 mg/dl in all cows, indicating there was no adverse effect of feeding treatments. However significantly more STP levels in blood (6.77 g/dl) was noticed when the cows were fed HCHO treated 70:30 sugras:SBM concentrates mixture with 2 % added urea diet (T_3) over T_1 control (6.45 g/dl), but non significantly different from that of feeding untreated 70:30 sugras:SBM concentrates mixture with 2 % added urea ration (T_2:6.68 g/dl). With regards to blood urea contents, the results revealed that feeding of 1.5 per cent formaldehyde treatment 70:30 sugras:SBM concentrates mixture with 2 % (T_3) and 3 % (T_5) urea supplementation ration to cows improved blood urea level of cows as blood urea contents (32.20 to 33.07 mg/dl) were significantly highest over that of feeding respective untreated concentrate in T_2 (31.36 mg/dl) and in T_4 (31.76 mg/dl) diets to cows. Moreover there was increase of 2.70 % in blood urea contents of cows on T_3 diet as compared to feeding of T_5 ration.

Animals exert sufficient physiological stress during lactation as a cow weighing 350 to 400 kg produces 1000 to 2000 kg of milk in a lactation which amount to 4 to 5 times of its own body weight. Obviously it becomes necessary to have a sound balanced feeding management in order to relieve the physiological stress on one hand and allow the animal to express its genetic potential of milk production. It is established that the variation in milk production of cows to the extent of 25 per cent are accounted to genetic makeup while non genetic factors had a role to the level of 5 per cent in expression of milk yield, of which feeding management is to be considered as a critical factor to influence milk yield of cows. Feeding management in reference to DM and protein intakes has positive significant impact on milk production and feeding of required amount of concentrates to fulfil nutritional demands would favour milk production. (Garg et al. 2007). Moreover, about 70 per cent of the total expenditure is increased on feeding of animals, there by directly related to economics of the dairy business. Considering these aspects, one has to pay due attention to feeding of cows in order to harvest maximum possible production and proper health care of cows.

However limited studies with regards to the effect of feeding formaldehyde treated soybean meal to lactating cows and buffaloes have been conducted so far as apparent from documented literature. Where a positive significant effect on increase in milk yield of cows, goats and sheeps was noticed due to feeding of formaldehyde treated SBM (Compeneere et al. 2010 and Doskey *et al.* 2012). Thus an attempt has been made in the present study to enhance the rumen by pass protein value of soybean meal (SBM) by treating with 1.5 per cent formaldehyde/ 100 g CP and its feeding effect on health of lactating cows in respect to Serum total protein and Serum total urea.

MATERIAL AND METHODS

The present investigation entitled "Effect of Formaldehyde Treated Concentrate, Urea and Soybean Meal on Serum total protein and Serum total urea of lactating cows" was carried out at Livestock Instructional Farm, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola for a experimental period of 90 days with 10 days prior pre experimental period. Twenty five early to mid-lactation stage lactating cows were selected from the herd on the basis of nearness in stage of lactation, milk production and body weight. The selected cows were divided in the five groups on the basis of nearness in different productive characters.

The maintenance and milk production

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requirements of the cows were worked out on the basis of the thumb rules suggested by Jagdish Prasad and Neeraj (2008) and Banerjee (2008). The cows in all the treatments (T_1 to T_5) were given 5 kg green Hy. Napier and one kg sugras milk ration grade 1 (17.60% CP) to fulfill the maintenance requirements. Treatments were planned like T_1 – Wheat straw + sugras concentrate (17.60 % CP) 40 % of milk yield (production ration), T_2 – Wheat straw + untreated 70:30 sugras:SBM mixture (27.47 %CP) 30% of milk yield (75%of production ration) + 2% urea of the production quantity, T_3 – Wheat straw + 70:30 sugras:SBM mixture (27.47 %CP) treated with HCHO at 1.5 g/100CP 30% of milk yield (75% of production ration) + 2 per cent urea of the production quantity, T_4 - Wheat straw + untreated 70:30 sugras:SBM mixture (27.47 %CP) 20% milk yield (50% of production ration)+ 3 per cent urea of the production quantity and T_5 – Wheat straw + 70:30 sugras:SBM mixture (27.47 %CP) treated with HCHO at 1.5 g/100CP 20 per cent milk yield (50% of production ration) + 3 per cent urea of the production quantity.

Blood collection and preparation of Serum

All the animals from each group were subjected to blood collection. Collection of blood was carried out early in the morning before feeding and watering of animals. The blood samples were collected from the jugular vein with sterile hypodermic needle (No. 18) in two sterile vials, one for serum and other containing sodium fluoride for hematological studies. 2 ml of blood was collected from jugular vein in sterile vial containing one to two drops of EDTA Solution at the rate of 5 mg/ml of blood. For separation of serum, about 10 to 15 ml of blood was collected in sterile test tubes without any anticoagulant. Collected blood was allowed to clot in the test tube in slanting position at room temperature for 24 hrs. The clean serum was separated in oven dried vials. The samples were properly labeled. The vials were packed tightly with plastic cover and were stored in deep-freezer at -20^{0}C until used for biochemical analysis.

Laboratory investigation

Laboratory investigation for haematological studies of blood profile of total serum protein, blood urea nitrogen was carried out by using Auto-analyzer in the laboratory of Veterinary Clinic of Post Graduate Institute of Veterinary and Animal Sciences, Akola

Biochemical analysis of blood

a) Serum total protein (gm/dl)

Serum total protein was estimated with the help of diagnostic kit by modified Biuret end point colorimeter (Vatzidis, 1977).

b) Serum total urea

Blood urea nitrogen (BUN) and blood urea was estimated with the help of diagnostic kit as per procedure described by Chouhan (2003) and Brar *et al.* (2011)

The data were arranged in factorial randomized block design (FRBD) and analyzed by standard statistical method as per Amble (1975).

RESULTS AND DISCUSSION

Metabolic Blood Profile

The feeding of 1.5 per cent formaldehyde concentrate with added urea ration to cows neither influenced adversely the feed intake nor performance of cows. However, it is essential to evaluate whether this feeding approach had any effect on health status of cows or otherwise judged on the basis of some metabolic blood profile parameters. It is reported that blood urea nitrogen (BUN) could serve a good indicator of concentration of rumen ammonia which was related to solubility of nitrogen compounds fed. Moreover, protein source and energy level in diet were important to influence on plasma urea concentration (Spain *et al.*, 1989 and Polat *et al.*, 2009). Considering these views emphasis was given in present study to estimate total serum protein and blood urea contents. The data obtained in this respects are discussed under metabolic blood profile of cows.

It is evident from Table 1 that the initial STP contents were ranging from 6.09 to 6.35 g dl^{-1} with overall average of 6.64 g/dl amongst the treatment cows. This means all the cows were possessing normal STP value as per prescribed normal standards of 6 g dl^{-1} suggested by Gopal Krishana (2012) in cattle. Moreover, irrespective of treatments STP levels exhibited increasing trend from that of initial value 6.24 g dl^{-1} with the progress of feeding trial, the values being 6.52, 6.71, 7.09, g dl^{-1} during 1st (December), 2nd (January) and 3rd (February) months of trial respectively. As a result, STP levels showed an increase of 4.48, 2.91 and 5.66 per cent in 1st, 2nd and 3rd month as compared to STP content of previous month.

Serum Total Protein (STP)

The data obtained on effect of feeding treatments and period of feeding trial on STP content of cows was tabulated and presented in Table1.

Table 1: Average month wise serum total protein content (gm/dl) on feeding of different treatments to lactating cows over experimental period

Month	Treatments					Mean
	T_1	T_2	T_3	T_4	T_5	
P_1 –Initial	6.29	6.09	6.21	6.35	6.26	**6.24** [a]
P_2 - Dec.	6.45	6.50	6.59	6.55	6.50	**6.52** [b]
P_3 –Jan	6.35	6.92	6.81	6.72	6.78	**6.71** [c]
P_4 - Feb	6.69	7.22	7.47	6.99	7.11	**7.09** [d]
Mean	**6.45**[a]	**6.68**[bc]	**6.77**[b]	**6.65**[c]	**6.66**[c]	**6.64**
	PERIOD	TREATMENT		Interaction P x T		
F test	SIG	SIG		SIG		
SE (m) ±	0.029	0.326		0.652		
CD at 5%	0.080	0.090		0.180		
CV%	2.194					

(Pooled treatments means in row and pooled period means in column with similar superscripts do not differ significantly)

Table 1 indicates that feeding treatments influenced significantly STP content in cows. The increase from initial content was 6.29 to 6.69, 6.09 to 7.22, 6.21 to 7.47, 6.35 to 6.99 and 6.26 to 7.11 g/dl at 91 days of trial in T_1, T_2, T_3, T_4 and T_5 groups respectively with corresponding increase of 6.30, 18.55, 19.32, 10.07 and 13.57 per cent over that of their initial values respectively. As a result, the average STP value of blood in cows was significantly more (6.77 g/dl) when cows were fed HCHO treated concentrate mixture with 2 per cent added urea (T_3) ration over that of T_1, control, T_4 and T_5 treatments. While significantly less (6.45 g/dl) was noticed on feeding T_1 control diet to cows as compared to rest of the groups. Moreover STP levels recorded in blood of T_3 cows was also significantly more than that of STP content noticed under T_4 (6.65 g/dl) and T_5 (6.66 g/dl) treatments. However, the differences in STP levels between T_2 and T_3 as well as between T_4 and T_5 were found non significant. This trend gets support of Chandler et al. (1968) as they noticed that protection of protein had a tendency to raise STP due to better utilization of dietary proteins. Beside this Shamoon *et al.* (2009) noted that feeding of untreated or HCHO treated concentrated with added urea to sheep did not influence STP level, being 6.62 and 6.85 g/dl respectively. This observation is in agreement with present result observed between T_2 and T_3 and between T_4 and T_5 treatments where addition of urea with untreated and HCHO treated ration did not influenced STP level in cows.

Thus it appears further from the results that level of added urea (2 or 3%) was not the factor to affect STP content in cows otherwise the STP levels could not have decreased in T_5 as compared to T_3 treatment containing 3 and 2 per cent added urea to HCHO treated concentrate diet respectively. Hence, the results suggest that feeding of HCHO treated 70:30 sugras:SBM concentrate with 2 per cent (T_3) or 3 per cent (T_5) added urea ration or same but untreated rations (T_2 and T_4) to cows were more advantageous for improving STP levels in cows as compared to T_1 control. Moreover T_3 treatment was found more effective to carry out improvement in STP levels of cows in comparison to T_5 treatment. The increase intake of CP on T_3 diet might be the cause to raise STP levels in blood of cows as compared to T5 cows. Polat *et al.* (2009) opined that STP concentration increased when CP content exceeded the requirement and total protein measurement could reflect nutritional status in animal while Hagawane *et al.* (2009) suggested that total protein levels are usually use as an appraisal of nutritive status of an animal. These view strengthened the present trend of results on improvement of STP status on feeding HCHO treated or untreated concentrate with added urea rations with 27.47 per cent CP to cows as compared to control diet (17.60% CP). However, Mondal and Chopra (2008) did not observe significant effect of RDP:UPD ratio of the diet on STP content which does not support present results as HCHO treatments to concentrate with 3 per cent added urea (T_5) is expected to have lower UDP levels in ration in comparison to HCHO treated concentrate with 2 per cent added urea (T_3) rations.

Moreover Oldham *et al.* (1982), Bhagwat and Srivastava (1993), Sahoo and Walli (2005) and Shamoon *et al.* (2009) did not notice significant influence of feeding HCHO treated SBM to cows, soybean cake to calves, mustard cake to goat, and barley grain to sheep on STP content, respectively, though STP values were higher on HCHO treated diets. These observations are supportive

to present result on the ground that T_2 and T_3 as well as T_4 and T_5 treatments were at par in respect of STP contents in cows.

Blood Urea Content (BU)

Different feeding treatments along with its interaction with experimental period exhibited a significant effect on blood urea content in cows as evident from Table 2 and Table 3 of mean sum of squares. The milking cows reared on T_3 and T_5 HCHO treated 70:30 sugras:SBM concentrate with 2 and 3 per cent added urea ration recorded significantly higher blood urea level of 33.07 and 32.20 mg/dl, respectively over rest of the treatments groups. However the differences between T_3 and T_5 were found significant. In contrast significantly lowest blood urea level of 30.21 mg/dl was noticed on feeding T_1 control diet while blood urea levels of T_2 and T_4 cows occupied intermediate position being 31.36 and 31.76 mg/dl respectively. In spite of this the blood urea content of all cows were within prescribed limit of 12 to 58 mg/dl (Gopal Krishana, 2012).

Table 2: Average month wise Blood Urea protein content (mg/dl) on feeding of different treatments to lactating cows over experimental period

Month	Treatments					Mean
	T_1	T_2	T_3	T_4	T_5	
P_1 –initial	29.48	30.17	30.20	29.86	29.96	**29.93**[a]
P2 – Dec.	30.24	30.62	32.17	30.65	31.57	**31.05**[b]
P_3 – Jan.	30.52	31.58	33.74	32.46	32.80	**32.22**[c]
P_4 – Feb.	30.62	33.07	36.16	34.09	34.45	**33.68**[d]
Mean	**30.21**[a]	**31.36**[b]	**33.07**[c]	**31.76**[d]	**32.20**[e]	**31.72**
	PERIOD		TREATMENT		Interaction P x T	
F test	SIG		SIG		SIG	
SE (m) ±	0.095		0.106		0.213	
CD at 5%	0.265		0.296		0.593**	
CV%	1.508					

(Pooled treatments means in row and pooled period means in column with similar superscripts do not differ significantly)

Table 3: Mean sum of squares (MSS) of Blood Urea Protein and Serum total protein

Source	df	MSS	
		Blood Urea Protein	Serum Total Protein
Replication	4	2.787	0.0083
Treatment	4	22.259	0.281
Period	3	64.49	3.228
Treatment x period	12	3.233	0.142
Error	76	0.228	0.0212

Thus, there was improvement in blood urea levels of cows as a result of feeding formaldehyde treated concentrate with added urea ration. Feeding of HCHO treated concentrate with 2 per cent (T_3) and 3 per cent (T_5) added urea ration increased blood urea by 4.45 and 1.38 per cent over that of feeding untreated concentrates with 2 per cent (T_2) and 3 per cent (T_4) added urea diets respectively. Moreover, there was 2.70 per cent increase in blood urea on T3 as compared to T_5 group. These results get support of Doskey *et al.* (2001) where they noticed increase in blood urea by 11 per cent due to feeding of urea treated straw with formaldehyde treated barley grains. While blood urea levels were less by 8 per cent on feeding untreated concentrates with urea treated straw than that of feeding urea treated straw + formaldehyde treated concentrates. According to them reduction in starch degradability and energy available to the rumen microorganism to utilize nitrogen causing an increase in ammonia absorption through rumen wall and increased blood urea concentration. However, Shamoon *et al.* (2009) reported that feeding of formaldehyde treated proteins to sheep had no significant effect on blood urea levels ranging from 27.08 to 51.09 mg/dl. This observation is contradictory to present results in respect of the trend and higher values of blood urea than that of present values. On the other hand Mondal and Chopra (2008) opined that serum urea which is an indicator of protein status in animal varied with protein quality and quantity in feed. According to them there was decrease by 17.40 per cent in serum urea due to addition of higher RDP:UDP (50:50) ration in diet against a ration of 70:30 RDP:UDP in ration. This explanation does not support to present results as blood

urea levels on feeding HCHO treated concentrate with 3 per cent added urea ration showed a decrease in blood urea level over that of feeding HCHO treated concentrate with 2 per cent added urea diet to cows. In other words 1.5 per cent formaldehyde treatment to concentrates with 3 per cent added urea might have raised the RDP proportion in ration in comparison to ration formed in formaldehyde treatment with 2 per cent added urea diet.

With regards to the effect of experimental period on blood urea content, it was recorded that there was significant increase in content with the advancement of period. Irrespective of treatments maximum value of 33.68 mg/dl was reached at 90th day of the trial from the initial value of 29.93 mg/dl, indicating an increase of 12.53 per cent. However the change in blood urea content showed a variation between the treatments were maximum values were reached to 30.62, 33.07, 36.16, 34.09 and 34.45 mg/dl on 90th day of trial under T_1, T_2, T_3, T_4 and T_5 groups respectively. This means a corresponding rise of 3.86, 9.61, 19.73, 14.16 and 14.98 per cent over that of initial values of 29.48, 30.17, 30.20, 29.86 and 29.96 mg/dl values respectively. This trend does indicate that feeding of HCHO treated 70:30 sugras:SBM concentrate with 2 per cent (T_3) and 3 per cent (T_5) added urea rations were beneficial to improve the blood urea status in cows as compared to feeding of T1 control diet or feeding of untreated rations with added urea. (T_2 and T_4). This trend might have aroused on account of supply of better plane of nutrition in T_3 and T_5 groups, there by increased total protein concentration in blood. However this logic does not get support of observations reported by Bhagwata and Srivastawa (1993) and Sahoo and Walli (2005) where they noticed decrease in plasma urea as a result of feeding HCHO treated diet to calves and goats. They attributed this decrease to (1) reduced degradation of protein in rumen (2) decrease ammonia production in rumen and assimilation in blood (3) increased efficiency of utilization of amino acids absorbed from post rumen region.

Thus provision of 1.5 per cent HCHO treated concentrate with 2 per cent added urea ration to cows can be adopted without exerting any detrimental impact on STP and blood urea parameters of metabolic blood profile of cows.

CONCLUSION

The results on metabolic blood profile of cows in reference to serum total protein (STP) and blood urea (BU) contents, it was observed that the levels of these two parameters were found within the normal range of 6 g/dl and 12 to 58 mg/dl in all cows, indicating there was no adverse effect of feeding treatments. However significantly more STP levels in blood (6.77 g/dl) was noticed when the cows were fed HCHO treated 70:30 sugras:SBM concentrates mixture with 2 per cent added urea diet (T_3) over T_1 control (6.45 g/dl), but non significantly different from that of feeding untreated 70:30 sugras:SBM concentrates mixture with 2 per cent added urea ration (T_2:6.68 g/dl). Moreover STP levels noticed on feeding untreated (T_4) and HCHO treated (T_5) 70:30 sugras:SBM concentrates mixture with 3 per cent added urea diet were significantly lower (6.65 and 6.66 g/dl) than that of T3 STP levels of cows, indicating that level of added urea was not the factor to affect STP levels in blood of cows. The increase intake of CP on T_3 diet might be the reason to raise STP levels in blood of cows as compared to T5 and T_1 groups.

With regards to blood urea contents, the results revealed that feeding of 1.5 per cent formaldehyde treatment 70:30 sugras:SBM concentrates mixture with 2 per cent (T_3) and 3 per cent (T_5) urea supplementation ration to cows improved blood urea level of cows as blood urea contents (32.20 to 33.07 mg/dl) were significantly highest over that of feeding respective untreated concentrate in T_2 (31.36 mg/dl) and in T_4 (31.76 mg/dl) diets to cows. Moreover there was increase of 2.70 per cent in blood urea contents of cows on T_3 diet as compared to feeding of T_5 ration.

Hence the results indicated that provision of 1.5 per cent formaldehyde treated concentrates with 2 % added urea ration to cows can be adopted without excreting any detrimental impact on STP and BU levels of cows.

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Studies on Supplementation of Probiotics on Feed Consumption, Water Intake and Body Weight Gain of Giriraja Poultry Birds

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ABSTRACT

The present investigation entitled "Studies on supplementation of probiotics on Feed consumption, Water intake and Body Weight gain of Giriraja poultry birds" was carried out to assess the effect of feeding probiotics on Feed Consumption, Water intake and Body weights gain of Giriraja poultry birds. Straight run 90, day old commercial Giriraja chicks were procured from Govt. hatchery. They were randomly and equally distributed in to three treatment groups *viz*, T_1, T_2 and T_3 with 30 chicks in each group, on equal weight basis. The birds were randomly divided into five replicate groups of each treatment and the chicks were housed in separate compartments. Multistrain probiotics were added in experimental ration at different levels. The dietary treatments consisted of one basal control (T_1), supplemented with 0.10% probiotics (T_2) and 0.15 per cent probiotics (T_3). The average feed consumption at 7th week of age for treatment T_1, T_2 and T_3 were 673.83, 675.33 and 677.66 g, respectively. The higher feed consumption was observed in T_1 followed by T_2 and T_3. The average water consumption at 7th week of age for treatment T_1, T_2 and T_3 was recorded as 2161.66, 2163.33 and 2165.00 ml/birds/week, respectively. The higher water consumption was observed in treatment T_3 followed by T_2 and T_1. The corresponding average live body weights at the end of seven weeks of age were recorded as 1095.72, 1210.59 and 1305.25 g for T_1, T_2 and T_3 treatment, respectively. Average weekly live body weight gain was recorded as 151.92, 166.25 and 181.83 for T_1, T_2 and T_3 respectively. These denotes that supplementation of probiotics is beneficial and positively affected on the live body weight gain of Giriraja poultry birds.

Poultry industry is a fast growing segment of Indian economy, contributes about eight per cent of the gross national income. Modern intensive poultry industry demands more rapid growth in a confined housing environment which leads to greater susceptibility to stress in broilers. The potential of poultry sector in employment generation and enhancing rural incomes is well-recognized. Over 5 million people are directly or indirectly engaged in poultry sector, apart from numerous small poultry keepers in rural and tribal areas of the country. The domestic broiler meat demand is expected to grow at around 15-18 per cent, while table egg demand is expected to grow at 5-7 per cent in medium to long term. Indian poultry industry is growing at an estimated rate of 6-7 per cent per annum for egg and 15-20 per cent for meat. India's contribution to world's egg production is 4 per cent and chicken production is 2 per cent whereas, poultry sector contributes 3 per cent to national GDP and 10 per cent of total livestock GDP (Saxena, 2009).

Indian rural poultry farming by developing and releasing a synthetic colored dual-purpose strain namely "GIRIR-AJA". Symbolically expressed, Giriraja stands for king of the jungle fowl. It is a strain bred to resemble local fowls. Sturdy and resistant, it can easily acclimatize itself to any region and weather. Giriraja yields high quality and quantity of meat and eggs which can survive like any native stock, except for the routine rank. In other word, Giriraja is a miracle fowl.

Feed supplement and feed additives has served the purpose of best production efficiencies over the years. Potential of birds is fully utilized by such feed formulation and feeding practices. Combination of probiotics and prebiotics are known as synbiotics where the efficiency of probiotics is enhanced by the inclusion of specific prebiotic. The beneficial effect of probiotic and prebiotics achieved through modification of intestinal microbes, stimulation of immunity system, reduction of inflammatory reaction, prevention of pathogen colonization enhancement of performance, decrease carcass contamination etc. (Simmering and Blaut, 2001).

Hence taking into consideration the present investigation was planned with main objective to find out the effect of probiotics on feed consumption, water intake and body weight gain of Giriraja poultry bird.

MATERIAL AND METHODS

The present research work was planned to evaluate the effect of Supplementation of probiotics on

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growth performance of Giriraja poultry birds." Present study was carried out in the Dept of Animal Husbandry and Dairy Science, Dr.PDKV, Akola and Dept. of Poultry Science, Post Graduate Institute of Veterinary and Animal Sciences, Akola, during the year 2015-16 (MAFSU). The probiotics was procured from local market of Akola as feed additives for conducting the feeding trial on Giriraja bird. Total 90 chicks of day old age, belongs to Giriraja breed were procured from Government Hatcheries, Tapovan Amravati (Maharashtra). Experimental chicks were weighed and distributed randomly in to three treatment groups *viz*, T_1, T_2 and T_3 with 30 chicks in each group, on equal weight basis. The birds were randomly divided into five replicate groups of each treatment and the chicks were housed in separate compartments.

All the chicks were fed with ground maize for first two days of age. For the experiment, a commercial Starter (0-3 weeks) and finisher (4-6 weeks) crumbles were used during experimental period of 6 weeks. Fresh, clean and cool drinking water was provided to the experimental bird *ad-libitum*. All the precautionary measures against diseases were taken throughout the experimental period of eight weeks. The dietary treatments were consisted as, T_1 (Standard ration), T_2 (Standard ration + 0.10% probiotic) and T_3 (Standard ration + 0.15% probiotic). The diets were fed *ad-libutum* to experimental birds. The experimental chicks were weighted individually at weekly interval up to the six weeks using electronic balance. Weekly feed consumption, cumulative feed consumption and water intake was worked out for all the treatment groups. The data was analyzed by using Completely Randomized Designs (Amble, 1975).

RESULTS AND DISCUSSION

Average weekly feed consumption :

The feed consumption of experimental chicks was recorded at weekly interval throughout the experimental period. The average weekly feed consumption of Giriraja chicks was presented in Table 1.

The average feed consumption during first week of age for T_1, T_2 and T_3 were 71.00, 73.00 and 73.66 g respectively. The average feed consumption at 7th week of age for treatment T_1, T_2 and T_3 were 673.83, 675.33 and 677.66 g, respectively. The higher feed consumption was observed in treatment T_1 followed by T_2 and T_3. The significant difference in weekly feed consumption was found from 4th week onward. The trend of significantly feed consumption was recorded in T_1 (673.83), T_2(675.33) and T_3(677.66) groups during 4th to 7th week.

Results recorded by some of research worker as discussed below were in agreement with present results. Patel *et al.* (2015) conducted trial on two hundred and forty (n=240), day-old broiler chicks of strain 'cobb400' were divided equally into 3 groups of 80 chicks each in group to observe the effect of probiotics (Protexin) supplementation on growth performance and economics of feeding in broilers. Different dietary treatments were T_1– basal diet without probiotics supplementation (control), T_2–T_1 + probiotics supplementation (50 g/ton of feed) and T_3– T_1 + probiotics supplementation (100 g/ ton of feed) and found that feed intake during starter, finisher and overall study period remained statistically (Pe"0.05) at par non significance. Likewise, Nawaz et al. (2016) evaluated effect of probiotics on growth

Table 1. Average weekly feed consumption of Giriraja Birds (g/bird)

Treatment	1st week	2nd week	3rd week	4th week	5thweek	6th week	7thweek	Treatmentmean
T_1	71.00	156.16	304.16	381.50	447.00	617.16	673.83	378.68
T_2	73.00	156.66	305.66	383.00	448.66	620.00	675.33	380.33
T_3	73.66	157.00	306.00	384.33	450.33	621.33	677.66	381.47
Weekmean	72.55	156.60	305.27	382.94	448.66	619.49	675.60	
'F' test	NS	NS	NS	NS	S	S	S	
SE(m)±	0.865	0.804	0.854	0.888	0.627	0.907	0.942	
CD	2.665	2.479	2.632	2.736	1.933	2.797	2.903	

(NS: Non significant, S: significant)

performance, nutrient digestibility and carcass characteristics in broilers and results showed improved feed intake due to the addition of yeast, Toyocerine® and mixture of both (yeast + Toyocerine®) @ 0.2 per cent of feed compared to the control group (Table 2). The highest feed intake was observed in birds fed diet supplemented with yeast followed by those fed diet supplemented with Toyocerine® and birds fed diet supplemented with mixture of both yeast + Toyocerine®.

Average Cumulative feed consumption of Giriraja poultry birds

The data recorded on average cumulative feed consumption per bird from first to seventh weeks in different treatment groups was analyzed, tabulated and presented in Table 2.

The cumulative feed consumption at seventh weeks of age were 2650.66, 2662.31 and 2669.65 g respectively in T_1, T_2 and T_3 treatments groups. The cumulative feed consumption of giriraja poultry birds for the treatment group T_1 was lesser as compared to T_2 and T_3 group. The significant difference in cumulative weekly feed consumption was found from second week onward. The trend of significantly cumulative feed consumption was recorded in T_1 (2650.66), T_2 (2662.31) and T_3 (2660.87) groups during forth to seventh week.

Naik *et al.* (2014) conducted experiment at poultry farm, Bheemarayanagudi using 90 day old Giriraja chicks, The two treatment groups T_1: control with synthetic methionine without Methionine producing probiotics, T_2: with Methionine producing probiotics without synthetic methionine and results found that cumulative feed consumption (g) varies non significantly (P>0.05) from 1747.7g (T_2) to 1789.3g (T_1). The feed intake increase in methionine producing probiotics, this might be due to increase in digestibility of nutrients contributed by harmless microbes. Likewise, Raka *et al.* (2014) conducted trial on the effects of Liquid Probiotic Mixed Culture (LPMC) on laying hens performance were studied. One hundred twenty eight 44-wk-old Isa Brown layers were randomly divided into 2 groups with 64 laying hens or layers in two groups. Layers in first group were fed with commercial feed as antibiotic contained diets; the other fed with self-mixed feed as antibiotic free diets. Both of groups had different LPMC level: control, 0.15 %, 0.30 % and 0.45 % of LPMC (v/v) added in water and he found that feed group 1(A1) was commercial feed as antibiotic contained diets has the highest result on feed consumption was found on 0.45 % (v/v) LPMC supplementation (119.96+0.06) and lowest on 0.15 % (v/v) LPMC supplementation (119.79+0.12).These results are confirming the results of present study.

Average weekly water intake

The data obtained in respect to average weekly water consumption from first to seventh weeks in different treatment groups was analyzed tabulated and presented in Table 3.

The average water consumption at 7th week of age for treatment T_1, T_2 and T_3 was recorded as 2161.66, 2163.33 and 2165.00 ml/birds/week respectively. The higher water consumption was observed in treatment T_3 followed by T_2 and T_1. Zulkifli *et. al.* (2006) conducted trial

Table 2. Average Cumulative feed consumption of Giriraja Birds (g/bird)

Treatment	1st week	2nd week	3rd week	4th week	5thweek	6th week	7thweek	Treatmentmean
T_1	71.00	227.16	531.16	912.73	1359.73	1976.82	2650.66	1104.18
T_2	73.00	229.66	535.32	918.32	1366.98	1986.98	2662.31	1110.36
T_3	73.66	230.66	536.66	920.99	1370.66	1992.00	2669.65	1113.46
Weekmean	72.55	229.16	534.38	917.34	1365.79	1985.27	2660.87	
'F' test	NS	S	S	S	S	S	S	
SE(m)±	0.8651	0.7982	0.7026	0.8120	0.7362	0.9007	0.9777	
CD	2.6658	2.4597	2.1650	2.5022	2.2684	2.7753	3.0127	

(NS: Non significant, S: significant)

Table 3. Average weekly water intake of Giriraja Bird (ml/bird)

Treatment	1st week	2nd week	3rd week	4th week	5thweek	6th week	7thweek	Treatmentmean
T_1	267.50	676.66	1076.66	1426.66	1783.33	2067.33	2161.66	1351.40
T_2	268.33	677.47	1078.33	1427.50	1784.84	2068.85	2163.33	1352.85
T_3	269.16	678.26	1079.16	1428.33	1785.60	2070.00	2165.00	1354.03
Weekmean	268.33	677.46	1078.05	1427.5	1784.59	2068.73	2163.33	
'F' test	NS	NS	NS	NS	NS	NS	NS	
SE(m)±	0.9891	0.8696	0.8064	0.6897	0.65077	1.1568	0.94106	
CD	3.047	2.680	2.485	2.1253	2.0052	3.5645	2.89971	

(NS: Non significant)

for response of heat-distressed broiler chickens to virginiamycin and probiotic-enhanced water acidifier Acid-Pak 4-WayTM) supplementation, and early age feed restriction and he founded that non significant differences were noted in the water consumption of control, VM, AP and F60 birds during the heat treatment period. The combined and individual effects of probiotic (*Saccharomyces cerevisiae*) and a commercial enzyme (Zyme®) were evaluated on weight gain, haematology and serum biochemistry of broiler chicken. Eighty day–old broiler chicks were randomly divided into 4 groups (P_1-P_4) of 20 birds each. Each group was subdivided into 5 replicates of 4 birds each. P_1 had no probiotic and no enzymes (control). P_2 had enzymes in water (0.02 ml/lit) but no probiotic. P_3 had enzymes in their water (0.02 ml/lit) and probiotic in their feed (0.8 g/kg). P_4 had probiotic in their feed (0.8 g/kg) but no enzymes in their water. The results of the experiments showed non significant difference (P>0.05) in water consumption among the experimental groups (Chuka, 2014). These findings are in agreement with the results of present investigation.

Average weekly live body weights

The data obtained in respect to average weekly live body weights of Giriraja poultry birds from day old to seven weeks age in all treatment groups was statistically analyzed, tabulated and presented in Table 4.

It was observed from the present study that the average live body weights of Giriraja poultry birds at day old stage were 32.30, 32.00 and 32.50g for the treatments T_1, T_2, and T_3 respectively. The initial body weights of Giriraja poultry birds were statistically non significant in all dietary treatments indicating that the treatments groups were homogenous. The corresponding average live body weights at the end of seven weeks of age were 1095.72, 1210.59 and 1305.25 g for T_1, T_2 and T_3 treatment respectively. The significant difference in weekly body weight was found from third week onward. The trend of

Table 4. Average weekly live body weights of Giriraja Birds (g/bird).

Treatment groups	Age in weeks							
	Initial weight	1st week	2nd week	3rdweek	4thweek	5thweek	6thweek	7thweek
T_1	32.30	94.72	195.89	340.84	510.56	690.38	890.36	1095.72
T_2	32.00	95.50	196.47	352.54	550.35	750.46	970.43	1210.59
T_3	32.50	96.85	197.53	410.37	610.10	820.48	1050.86	1305.25
'F' test	NS		S					
SE(m)±	0.5683	0.6209	0.5415	0.7719	0.5350	0.5896	0.7239	0.9522
CD	1.7512	1.9133	1.6685	2.3785	1.6487	1.8169	2.2308	2.9342

(NS: Non significant, S: significant)

significantly better growth was recorded in T_2 (1210.59) and T_3 (1305.25) groups during third to seventh week.

Khan *et al.* (2011) conducted study to evaluate three different probiotics, using drinking water supplemented with protexin, biovet and yoghurt. The day old broiler chicks were randomly divided into 12 separate floor pens each comprising 25 birds and three pens (replicates) per treatment group following completely randomized design. At 28 and 39 days of age body weight were determined. The body weight of birds given drinking water with probiotics was significantly greater than control (without probiotics) at both 28 and 39 days of age. Nagwa *et al.* (2014) allotted of 198 day old Arbor acres chicks and 198 Cobb300 were allotted into six groups (n=66) three for each breed, group one fed commercial broiler ration with BioGaurd (0.5g/kg ration) feed additives, group two fed commercial broiler ration with Micro BACLA (0.5g/kg ration) feed additive and last one fed commercial ration without additives and kept as control for the same breed. The obtained result showed that Arbor acres breed was superior to Cobb300 breeds in the final body weight (1970.0 vs. 1831.3 g). These results are in confirmation of present results.

Average weekly live body weights gain

The data recorded on the average weekly live body weight gain was statistically analyzed, tabulated and presented in Table 6.

The mean cumulative weight gain for T_1, T_2 and T_3 treatments were 62.42, 63.50 and 64.61 g respectively. The highest live body weight gain was observed for treatment T_3 (64.61g) followed by T_2, and T_1 groups. The analysis of variance showed that all treatment were statistically non significant up to 2nd week and thereafter from 3rd to 7th week average weekly live body weight were significant.

The cumulative body weight gain at 7th week of age for T_1, T_2 and T_3 groups were 205.36, 240.16 and 254.39 g, respectively. The higher weight gain was observed in treatment T_3 (254.39 g) followed by T_2 and T_1. The significant difference in weekly body weight gain was found from three week onward. The trend of significantly better growth was recorded in T_1 (205.36), T_2 (240.16) and T_3 (233.303) groups during third to seventh week. Average weekly live body weight gain under treatment mean was calculated as 151.92, 166.25 and 181.83 for T_1, T_2 and T_3, respectively were denoted that supplementation of probiotics was beneficial and positively affected on live body weight gain.

The results recorded in the present investigation were also supported and in agreement with result recorded by research worker. Amer and Khan (2012) studied conducted to compare probiotic with antibiotic, using drinking water supplemented with Biovet and TNF-60, and found that supplementation of antibiotic and probiotic indicated significantly increased ($p< 0.05$) the body weight gain of Desi chickens after 6 weeks of experiment. Likewise, Naik et al. (2014) conducted experiment at poultry farm, Bheemarayanagudi using 90 day old Giriraja chicks, The two treatment groups T_1: control with synthetic methionine without Methionine producing probiotics, T_2: with Methionine producing probiotics without synthetic methionine and results found that weekly body weight gains (g) varies non significantly between the treatments whereas the cumulative body weight gains varies significantly ($P < 0.05$) from 883 g (without methionine producing probiotics) to 955.7 g (with methionine producing probiotics). Patel et al. (2015) conducted trial on two hundred and forty (n=240), day-old broiler chicks of strain 'cobb400' were divided equally into 3 groups of 80 chicks each in group to observe the effect of probiotics (Protexin) supplementation on growth performance and

Table 4. Average weekly live body weights gain of Giriraja Birds (g/bird)

Treatment	1st week	2nd week	3rd week	4th week	5th week	6th week	7th week	Treatment mean
T_1	62.42	101.17	144.95	169.72	179.82	199.98	205.36	151.92
T_2	63.50	100.97	156.07	197.81	200.11	219.97	240.16	168.25
T_3	64.61	100.68	212.84	199.73	210.38	230.38	254.39	181.83
Week mean	63.51	100.94	171.287	189.087	196.77	216.777	233.303	
'F' test	NS	S						
SE(m)±	1.0065	0.7357	0.6759	0.7744	0.7812	0.9490	1.4521	
CD	3.1015	2.2669	2.0828	2.3862	2.4072	2.9242	4.4746	

(NS: Non significant, S: significant)

economics of feeding in broilers. Different dietary treatments were T_1– basal diet without probiotics supplementation (control), T_2 –T_1 + probiotics supplementation (50 g/ton of feed) and T_3–T_1 + probiotics supplementation (100 g/ton of feed). And found that average daily body weight gain (BWG) was significantly higher (Pd"0.01) in T_3 compared to T_2 and T_1 (41.63 ± 0.25 g vs 39.48 ± 0.15, 39.99 ± 0.10).

CONCLUSION

From the results obtained in present investigation is concluded that, The higher feed consumption was observed in treatment T_1 followed by T_2 and T_3. The significant difference in weekly feed consumption was found from forth week onward. The trend of significantly feed consumption was recorded in T_1 (673.83), T_2 (675.33) and T_3 (677.66) groups during forth to seventh week. The average water consumption at 7th week of age for treatment T_1, T_2 and T_3 was recorded as 2161.66, 2163.33 and 2165.00 ml/birds/week, respectively. The higher water consumption was observed in treatment T_3 followed by T_2 and T_1. The significant difference in weekly body weight gain was found from third week onward. The trend of significantly better growth was recorded in T_1 (205.36), T_2(240.16) and T_3(233.303) groups during third to seventh week. Average weekly live body weight gain as treatment mean was calculated as 151.92, 166.25 and 181.83 for treatment T_1, T_2 and T_3, respectively. It appears that inclusion of multistrain probiotic powder through drinking water improved feed consumption, water intake and beneficial and positively affected on live body weight gain.

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Effect of Formaldehyde Treated Concentrate, Urea and Soybean Meal on Intake and Digestibility of Nutrients in Lactating Cows

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ABSTRACT

Present investigation entitled "Effect of Formaldehyde Treated Concentrate, Urea and Soybean Meal on Intake and Digestibility of Nutrients in Lactating Cows" was undertaken at Department of Animal Husbandry and Dairy Science, Dr. PDKV, Akola. T_1 – Wheat straw + sugras concentrate (17.60 % CP) 40 % of milk yield (production ration), T_2 – Wheat straw + untreated 70:30 sugras:SBM mixture (27.47 % CP) 30 per cent of milk yield (75%of production ration) + 2 per cent urea of the production quantity, T_3 – Wheat straw + 70:30 sugras:SBM mixture (27.47 %CP) treated with HCHO at 1.5 g/100CP 30 per cent of milk yield (75% of production ration) + 2% urea of the production quantity, T_4 - Wheat straw + untreated 70:30 sugras:SBM mixture (27.47 %CP) 20% milk yield (50% of production ration)+ 3 per cent urea of the production quantity and T_5 – Wheat straw + 70:30 sugras:SBM mixture (27.47 %CP) treated with HCHO at 1.5 g/100CP 20% milk yield (50% of production ration) + 3 per cent urea of the production quantity.

SBM contained 49.50 per cent CP against a content of 17.60 per cent CP in sugras concentrate. The untreated 70:30 mixture had 27.47 per cent CP and 1.5 per cent HCHO treatment to mixture did not influence the intake and digestibility of nutrients. Per cent BW DMI under different treatments clearly indicated that the cows received sufficient DM to fulfill the appetite and consequently supply of nutrients to the body. The nutritive value in terms of DCP and TDN contents vary with narrow margin between the feeding treatments. Ration consisting wheat straw + Hy. Napier + HCHO treated 70:30 sugras:SBM concentrate with 2per cent added urea contained 10.95per cent CP, 6.62per cent DCP and 66.88 per cent TDN. The corresponding values for DCP and TDN were 6.08 and 63.51 % in T_1, 6.67 and 67.18 per cent in T_2, 6.62 and 66.88 per cent in T_3, 6.48 and 65.75 per cent in T_4 and 6.30 and 65.86 per cent in T_5 , respectively. Hence these not shows the adverse effect of feeding formaldehyde treated (1.5 g/100 g CP) concentrate with added urea ration to cows in reference to intake and digestibility of nutrients.

Livestock contributed 27 % of agriculture and allied GDP and therefore Government of India has targeted 4% growth in agriculture (Chakravarthy, 2010). This means a growth of 7.5 would be needed in livestock sector (Rekhate, 2010). Hence to cope up with the situation, it is necessary to maintained the present growth in milk production on one hand and to accelerate the milk production by 39% over the present level within a span of 8 to 10 years i.e. a production target of 150 million tonnes by 2020, to fulfil the demand of milk for human population on the other hand. However, the target is too achieved with available animal wealth, feed and fodder resources. In ruminants digestible protein entering the rumen is broken down by the rumen microbes to volatile fatty acids and ammonia or it accepts breakdown and passes to the small intestine where it is digested and absorb as amino acids. The fraction of feed protein that rumen degradation is called by-pass or rumen un-degradable protein (UDP) and fraction which undergoes degradation in rumen is termed degradable protein (RDP) (Sampath et al., 2004 and Mondal and Chopra, 2008). Feeding management in reference to DM and protein intakes has positive significant impact on milk production and feeding of required amount of concentrates to fulfil nutritional demands would favour milk production. (Garg et al., 2007). During couple of years it is noticed that the area under soybean crop has shown a growth of 15% in Maharashtra, giving a setback to cereals, pulses and oil seeds crops. Secondly, increased cost of GNC oil, people have motivated to soybean oil, resulting established of number of oil extraction plant at district level. This will boost to the availability of soybean meal on large scale. It is rich in protein (48 to 50% CP) against the established cakes (20 to 40% CP). Studies on feeding of formaldehyde treated GNC, mustard cake, sesame cake, rape seed cake and sunflower cake to large and small ruminants have been conducted in past. Positive significant effect on increase in milk yield of cows, goats and sheeps was noticed due to feeding of formaldehyde treated SBM (Compeneere et al., 2010 and Doskey et al., 2012). Thus, an attempt has been made in the present study to enhance the rumen by pass protein value of soybean meal (SBM) by treating

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with 1.5 per cent formaldehyde 100 g^{-1} CP and its feeding effect on lactating cows with main objective to find out the intake and digestibility if nutrients in lactating cows.

MATERIAL AND METHODS

The present investigation entitled "Effect of Formaldehyde Treated Concentrate, Urea and Soybean Meal on Intake and Digestibility of Nutrients in Lactating Cows" was carried out at Livestock Instructional Farm, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. 25 early to mid-lactation stage lactating cows were selected from the herd on the basis of nearness in stage of lactation, milk production and body weight. The selected lactating cows were divided in the five groups on the basis of nearness in different productive characters. The maintenance and milk production requirements of feed for the cows were worked out on the basis of the thumb rules suggested by Banerjee (2008). The cows in all the treatments (T_1 to T_5) were given 5 kg green Hy. Napier and one kg sugras milk ration grade 1 (17.60% CP) to fulfill the maintenance requirements. Treatments comprised of T_1 – Wheat straw + sugras concentrate (17.60 % CP) 40 per cent of milk yield (production ration), T_2 – Wheat straw + untreated 70:30 sugras:SBM mixture (27.47 % CP) 30 % of milk yield (75% of production ration) + 2% urea of the production quantity, T_3 – Wheat straw + 70:30 sugras : SBM mixture (27.47 % CP) treated with HCHO at 1.5 g 100 CP^{-1} 30 per cent of milk yield (75% of production ration) + 2 per cent urea of the production quantity, T_4 - Wheat straw + untreated 70:30 sugras:SBM mixture (27.47 % CP) 20 per cent milk yield (50 % of production ration) + 3% urea of the production quantity and T_5 – Wheat straw + 70:30 sugras:SBM mixture (27.47 % CP) treated with HCHO at 1.5 g/100CP 20 per cent milk yield (50% of production ration) + 3 per cent urea of the production quantity.

The Dry matter (DM), Crude Protein (CP), Ether Extract (EE), Nitrogen Free Extract (NFE). Crude Fiber (CF) and Total Ash (TA) was determined as per the standard procedures recommended by Indian Institute of Science BIS, ISI : 7874 (Part-1), 1975. The digestibility trial was conducted at the end of 120 days. The digestibility trial was conducted for a period of 14 days. Body weights of the experimental animals were recorded for three consecutive days before start of experiment and at the end of trial. The data were arranged in factorial randomized block design (FRBD) and analyzed by standard statistical method (Amble, 1975).

RESULTS AND DISCUSSION

Dry Matter Intake (DMI)

To confirm this contention, the DMI of cows was compared with standard norms of 2.5 kg DM 100 kg^{-1} body weight (Jagdish Prasad and Niraj, 2008). The data in this respect are shown in Table 1.

It is evident from Table 1 that the cows from all the treatments received sufficient dry matter to fulfill the feeding norms. On the contrary the cows reared on T_1 control and 2 per cent added urea formaldehyde concentrate mixture (T_3) ration had a advantage of receiving substantially more dry matter by 13.19 and 11.03 per cent over that of feeding norms, respectively. While the cows maintained on 2 per cent added urea untreated concentrate mixture (T_2) consumed marginally more DM (8.81%) than that of feeding standards. In contrast, DMI on 3 per cent added urea untreated concentrate mixture (T_4) and 3 per cent added urea formaldehyde treated concentrate diets in cows were just sufficient to meet out the feeding norms, being excess by 0.14 and 2.71 per cent respectively. As a result, one could except no adverse effect of feeding HCHO treated concentrate with added urea to cows in reference to provide different nutrients for harvesting optimum milk production. The past workers like Yadav and Chaudhary (2004) recorded higher (2.57

Table 1: Average DMI (kg)/day of cows in comparison to feeding standards

Treatments	Body weight (kg)	DMI	DM requirement (2.5 kg % BW)	Per cent Excess/Deficit
T_1	282	7.98	7.05	+13.19
T_2	286	7.78	7.15	+08.61
T_3	283	7.85	7.07	+11.03
T_4	280	7.01	7.00	+00.14
T_5	281	7.21	7.02	+02.71

kg) per cent BW DMI in crossbred cows on feeding FA treated GNC diet over an intake of 2.41 kg on untreated diet while Bugalia et al. (2008 a) also observed higher intake (3.14 kg) of% BW DM in crossbred cows on feeding HCHO treated sesame cake against an intake of 2.63 kg per cent BW DMI on untreated diet. These observations do not agree with present as per cent BW DMI was more in control group over that HCHO treated group, but the per cent BW DMI noticed in the present study was higher than that of their values. On the other hand, Chatterjee and Walli (2003) noticed non significant differences in per cent BW DMI on feeding formaldehyde treated mustard cake to crossbred calves and Murrah buffaloes against the intake on respective untreated straw which do not support the present trend. However their per cent BW DMI values in the range of 2.08 to 2.38 kg appeared to be substantially lower than the present values of 2.56 to 2.77 kg/d/cow.

Thus the results on per cent BW DMI under different treatments clearly indicated that the cows received sufficient DM to fulfill the appetite and consequently supply of nutrients to the body. Because due to the unit body size intake of all the cows met out the nutritional standards of 2.5 kg DM 100 kg^{-1} body weight.

Daily nutrient intake

The intake of different nutrients were calculated from the availability of nutrients on the basis of composition through wheat straw, green Hy. Napier, sugras concentrates and 70:30 sugras:SBM mixture with added urea. The data in this respect are shown in Table 2.

It appears from Table 2 that the cows from all treatments not only fulfilled their appetite but consumed excess DM than that of recommended level of 2.5 kg DM/ 100 kg body weight. On an average per cent body weight worked out as 2.82, 2.72, 2.77, 2.50 and 2.56 kg under T_1, T_2, T_3, T_4 and T_5 treatments, respectively, being excess intake of 12.80, 8.80, 10.80 and 2.40 per cent expect T4 respectively.

The CP intake (CPI) in cows was affected significantly by the feeding treatments, being 0.76, 0.84, 0.86, 0.72 and 0.74 kg/d/cow on T_1, T_2, T_3, T_4 and T_5 treatments, respectively. This means the cows reared on untreated concentrates with 2 per cent urea (T2) and HCHO treated concentrate with 2 per cent urea (T_3) rations received significantly more CP by 10.53 and 13.16 per cent respectively against T_1 control group. On the contrary, CPI in cows fed with untreated concentrates with 3 per cent urea (T_4) and HCHO treated concentrate with 3 per cent urea (T_5) diets were significantly lower by 5.55 and 2.70 per cent respectively over that of T_1 control group. Moreover, there was non significant difference between T_2 and T_3 as well as between T_4 and T_5 treatments for CPI in cows. Though non significant, the higher CPI in T_3 over T_2 and in T_5 over T_4 might be due to higher DMI by the cows fed with 1.5 per cent HCHO treated concentrates with 2 and 3 per cent added urea ration. The past workers like Chatterjee and Walli (2003), Yadav and Chaudhary (2004), Bugalia et al. (2008a) and Bugalia and Chaudhary (2008) also reported CPI in cows at par between feeding of HCHO treated mustard cake, GNC, sesame cake and respective untreated cakes to buffaloes and cows respectively. Thus, CPI in cows was not hampered with the feeding of formaldehyde (1.5 $g100g^{-1}$ CP) treated

Table 2: Daily intake of different nutrients under different treatments (kg/d/cow)

Treatments	DM	CP	CF	EE	NFE
T_1	7.97 (2.82)[a]	0.76[a]	2.19[a]	0.20[a]	4.26[a]
T_2	7.78 (2.72)[b]	0.84[b]	2.2[b]	0.34[b]	4.06[b]
T_3	7.85 (2.77)[a]	0.86[b]	2.28[b]	0.39[c]	4.05[b]
T_4	7.01 (2.50)[c]	0.72[c]	2.12[c]	0.25[d]	3.62[c]
T_5	7.21 (2.56)[d]	0.74[c]	2.17[a]	0.26[d]	3.73[d]
F test	Sig.	Sig.	Sig.	Sig.	Sig.
GM	7.57	0.78	2.21	0.29	3.94
SE m $\pm$	0.041	0.007	0.012	0.003	0.022
CD at 5%	0.115	0.019	0.035	0.009	0.061

(Means with similar superscript/s in column do not differ significantly. Figures in parenthesis indicate % BW DMI)

concentrate with 2 per cent added urea diet. With regards to CF intake on different rations, it was noticed that T_2 and T_3 diets provided significantly more quantity of CF to cows over rest of the groups. On an average CF intake were 2.19, 2.29, 2.28, 2.12 and 2.17 kg/d/cow in T_1, T_2, T_3, T_4 and T_5 treatments respectively. With regards to availability of EE nutrient on different diets to cows it was observed that the cows from T_2, T_3, T_4 and T_5 groups received significantly more EE by 70.0, 95.0, 25.0, and 30.0 per cent respectively over that of T_1 control group. There were significant differences between the treatments in respect of supply of NFE nutrient to cows. The average intake of NFE in T_1 control group was significantly more by 4.92, 5.19, 17.68 and 14.21 per cent that that of T_2, T_3, T_4 and T_5 groups, respectively. Lower NFE content in 70:30 sugras:SBM mixture in relation to normal sugras concentrate might have reflected on NFE intake of the cows under T2 to T5 treatments in reference to control group. Thus, the results on daily intake of different nutrients clearly established that feeding of formaldehyde treated (1.5 g $100g^{-1}$ CP) 70:30 sugras:SBM concentrate mixture with 2 per cent added urea diet did not have any adverse effect on nutrient intake of cows.

Digestibility of Nutrients

The digestibility of nutrients was determined from nutrient intake and nutrient voided in faeces. The results obtained in this regard are presented in Table 3 and 4.

Table 3: Details of digestibility of different nutrients

S.N.	Particular	Nutrient	T_1	T_2	T_3	T_4	T_5
1	Average BW (kg)		282	286	283	280	281
2	DMI/day (kg)		8.30	8.00	8.25	7.60	7.75
3	Daily Nutrient Intake (kg)	CP	0.791	0.868	0.903	0.781	0.795
		CF	2.280	2.375	2.396	2.298	2.333
		EE	0.208	0.354	0.410	0.271	0.278
		NFE	4.436	4.229	1.256	3.925	4.009
4	Average daily dung (Kg)		16.96	16.76	17.18	15.86	16.23
5	DM in dung (%)		15.82	15.81	16.09	16.24	16.13
6	Daily nutrient voided in dung (kg)	DM	2.690	2.651	2.765	2.576	2.618
		CP	0.286	0.334	0.357	0.493	0.306
		CF	0.901	0.924	0.957	0.886	1.203
		EE	0.066	0.115	0.149	0.089	0.104
		NFE	1.370	1.321	1.311	1.241	1.219
7	Daily nutrient retention (kg)	DM	5.617	5.349	5.485	5.024	5.132
		CP	0.505	0.534	0.546	0.493	0.489
		CF	1.379	1.451	1.439	1.412	1.430
		EE	0.142	0.239	0.261	0.182	0.174
		NFE	3.066	2.908	2.945	2.684	2.790
8	Digestibility coefficient (%)	DM	67.68	66.86	66.48	66.10	66.22
		CP	63.82	61.84	60.48	63.10	61.46
		CF	60.48	61.11	60.05	61.43	61.31
		EE	68.35	67.48	63.65	67.07	62.66
		NFE	69.13	68.76	69.19	68.38	69.61
9	Nutritive value (%)	DCP	6.08	6.67	6.62	6.48	6.30
		TDN	63.51	67.18	66.88	65.75	65.86

Table 4: Effect of feeding different treatments on digestibility coefficient of different nutrients (%)

Treatments	DM	CP	CF	EE	NFE
T_1	67.88	63.82[a]	60.48	68.35[a]	69.13
T_2	67.86	61.84[b]	61.11	67.48[b]	68.76
T_3	66.48	60.48[c]	60.05	65.65[c]	69.19
T_4	66.10	63.10[d]	61.43	67.07[d]	68.38
T_5	66.22	61.46[b]	61.31	62.66[e]	69.61
F test	NS	Sig	NS	Sig	NS
GM	66.67	62.14	60.88	65.84	69.01
SE m $\pm$	0.226	0.115	0.428	0.138	0.407
CD at 5%	-	0.340	-	0.407	-

(Means with similar superscript/s in row do not direr significantly)

It was noted that DM digestibility was more for T_1 control group (67.68%) followed by T_2 (66.86%), T_3 (66.48%), T_5 (66.22%) and T_4 (66.10%). Majority of the past workers like Gupta and Walli (1987), Shamoon et al. (2009) and Yadav and Chaudhary (2010) opinioned that feeding formaldehyde treated GNC to lambs, SBM to sheep, proteins to cows, mustard cake to calves, GNC to kids, soya protein to cows, wheat bran + SBM with urea to cows and GNC to cows, respectively did not influence DM digestibility in animals.

In respect of CP digestibility on different feeding treatment it was that digestibility coefficients reached the level of significance amongst treatments. Significantly higher (63.82%) and lower (60.48%) was noted in cows on feeding T_1 normal control and HCHO treated concentrate with 2 per cent added urea (T_3) rations, respectively, indicated that there was decrease in digestibility of CP by approximately 3 units with the feeding of treated ration to cows. While the other groups were placed at intermediate position, being 61.84, 63.10 and 61.46 per cent in T_2, T_4 and T_5 treatments, respectively with significant differences between T_2 and T_4 and non significantly different between T_2 and T_5 groups. This trend thus supports the present results. Moreover, it appears from the past documented literature that there is difference of opinion in respect of CP digestibility on feeding formaldehyde treated concentrates to animals. Chatterjee and Walli (2003), Bugalia *et al.* (2008a), Shamoon *et al.* (2009) and Yadav and Chaudhary (2010) observed non significant effect of feeding formaldehyde treated cakes and concentrate on CP digestibility in animals. These observations do not agree with present results.

The CF digestibility was not influenced significantly by the feeding of formaldehyde treated concentrate with added urea to lactating cows. On an average the digestibility coefficient were 60.48, 61.11, 60.05, 61.43 and 61.34 per cent under T_1, T_2, T_3, T_4 and T_5 groups, respectively. This means there was no harmful effect on CF utilization in cows due to feeding of HCHO treated concentrates. This contention is supportive to strengthen the present results. While the results of Giri and Das (1993) and Ramchandra *et al.* (2005) are also supportive to present trend where they reported that feeding of HCHO treated concentrates did not influence CF digestibility in animals. The EE digestibility was significantly affected by the feeding treatments being 68.35, 67.48, 63.65, 67.07 and 62.66 per cent under T_1, T_2, T_3, T_4 and T_5 groups, respectively. Bhagwat and Srivastava (1991) observed improvement in EE digestibility due to feeding of HCHO treated soybean cake in cows. However NFE, digestibility did not differ significantly between the feeding treatments, indicating no harmful effect of feeding HCHO treated concentrate with added urea ration to cows. On an average NFE digestibility coefficient were 69.13, 68.76, 69.19, 68.38 and 69.61 per cent under T_1, T_2, T_3, T_4 and T_5 groups, respectively. These results get support of observations recorded by Ramchandra et al. (2005), Bugalia et al. (2008a) and Yadav and Chaudhary (2010) where they reported non significant effect on NFE digestibility by feeding formaldehyde treated concentrates to cows.

Thus in general, the results on digestibility of different nutrients demonstrated that feeding 1.5 per cent formaldehyde treated 70:30 sugras:SBM concentrate

mixture with either 2 or 3 per cent added urea ration to cows did no affect on availability of DM, CF, NFE to cows with slight reduction in the availability of CP and EE in reference to feeding of normal diet to cows

Nutritive value of different rations

The nutritive values of different rations were judge in reference to their CP, DCP and TDN contents. The data in this regard are shown in Table 5.

The ration formulated by incorporating 1.5 per cent HCHO treated 70:30 sugras:SBM concentrate mixture with 2 per cent added urea (T_3) was containing more CP (10.95%) while lower CP content (9.53%) was noticed in normal concentrate ration. However in terms of DCP content of rations, it was observed that there was marginal decrease of DCP content of T_1 control ration by 0.54 to 0.59 per cent and 0.22 to 0.40 per cent over that of T_2/T_3 and T_4/T_5 rations, respectively(Table 5).

Moreover, the TDN content of T_1 control ration was lower by 3.37 to 3.67 per cent and 2.24 to 2.37 per cent than that of T_2/T_3 and T_4/T_5 rations, respectively. This means treatment of 70:30 sugras:SBM ration with 1.5 per cent formaldehyde and 2 or 3 per cent added urea was advantageous to increase the nutritive value of ration. Higher CP and EE content in T_2 to T_5 rations might be the reason to raise DCP content of rations, ignoring the effect of lower digestibility of these nutrients as compared to T_1 control ration. It appears therefore from the nutritive value of different ration that all the rations were having the DCP content marginally higher than that of the level of 5.02 per cent recommended by ICAR (1985) for lactating animals. On the other hand TDN values of rations were found substantially higher than that of 52.67 per cent prescribed by ICAR (1985) for the ration of lactating animals. Thus, the trend did reveal that all the rations might have fulfilled the protein and energy requirements of maintenance and milk production in cows. Moreover, NR was ranging with narrow degree between the rations, being 1:9.44, 1:9.06, 1:9.09, 1.9.15 and 1:9.44 for T_1, T_2, T_3, T_4 and T_5 rations respectively. The ratio worked out as 1:46, 1:44, 1:45, 1:44 and 1:43 for T_1, T_2, T_3, T_4 and T_5 rations respectively. All the ratios are comparable with that of ICAR (1985) recommended ratio of 1:42. Thus there was no adverse effect of inclusion of 1.5 per cent HCHO treated 70:30 sugras:SBM concentrate with added urea in the ration of lactating cows.

CONCLUSION

The unit body size intake of all the cows met out the nutritional standards of 2.5 kg DM 100^{-1} kg body weight. The results on intake of different nutrients revealed that feeding of 1.5 per cent formaldehyde treated 70:30 sugras:SBM concentrate with 2 per cent added urea diet had a potential to provide more CP, CF and EE with marginally less NFE nutrient to cows in comparison to offering normal sugras concentrate diet to cows.

The nutritive value in terms of DCP and TDN contents vary with narrow margin between the feeding treatments. Ration consisting of wheat straw + Hy. Napier + HCHO treated 70:30 sugras:SBM concentrate with 2 per cent added urea contained 10.95 per cent CP, 6.62 per cent DCP and 66.88 per cent TDN. Hence, it seems no reason to consider the adverse effect of feeding formaldehyde treated (1.5 g 100 g^{-1} CP) concentrate with added urea ration to cows in reference to intake and digestibility of nutrients.

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Table 5: Nutritive value of different feeding treatments

Treatments	Nutritive Value %			Nutritive Ratio
	CP	DCP	TDN	NR
T1	9.53	6.08	63.51	1:9.44
T2	10.79	6.67	67.18	1:9.06
T3	10.95	6.62	66.88	1:9.09
T4	10.27	6.48	65.75	1:9.15
T5	10.26	6.30	65.86	1:9.44

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Studies on Supplementation of Probiotics on Feed Conversion Efficiency, Dressing Percentage and Economics in Rearing of Giriraja Poultry Birds

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ABSTRACT

The present investigation entitled "Studies on supplementation of probiotics on Feed conversion efficiency, dressing percentage and economics in rearing of Giriraja poultry birds" was carried out to assess the effect of feeding probiotics on Feed Consumption, Water intake and Body weights gain of Giriraja poultry birds. 90, day old straight run commercial Giriraja chicks were procured from Govt. hatchery Tapovan, Amaravati. They were randomly and equally distributed in three treatment groups *viz*, T_1, T_2 and T_3 with 30 chicks in each group, on equal weight basis. The birds were randomly divided into five replicate groups of each treatment and the chicks were housed in separate compartments. Multistrain probiotics were added in experimental ration at different levels. The dietary treatments consisted of one basal control (T_1), supplemented with 0.10 per cent probiotics (T_2) and 0.15% probiotics (T_3). The average weekly feed efficiency at seventh week age were 2.49, 2.26 and 2.14, in T_1, T_2 and T_3 treatments groups, respectively. The cumulative feed efficiency of various groups T_1, T_2 and T_3 were found as 3.28, 2.81 and 2.66, respectively. The effect of probiotics feeding on dressing percentage was found beneficial which affect positively on dressing percentage. Dressing percentage was recorded as 59.54, 63.30 and 65.77 percent for treatment T_1, T_2 and T_3, respectively. The net profit per bird was highest in T_3 (Rs.140.16) followed by T_2 (126.72) and lower in T_1 (Rs.109.41).

Indian poultry industry has made a tremendous and remarkable progress evolving from a small scale backyard venture to the status of commercial, full fledge, self-sufficient and most progressive agro based industry and become an attractive enterprise particularly because of the small capital investment, increased returns, quick turn over, comparatively less risk involved, low land requirement, ease of production and high feed efficiency. Indian poultry industry is growing at an estimated rate of 6-7 per cent per annum for egg and 15-20 per cent for meat. India's contribution to world's egg production is 4 per cent and chicken production is 2 per cent whereas poultry sector contributes 3 per cent to national GDP and 10 per cent of total livestock GDP (Saxena, 2009). Feed supplement and feed additives has served the purpose of best production efficiencies over the years. Potential of birds is fully utilized by such feed formulation and feeding practices. At present numbers of feed additives are used to feed broiler birds for the purpose of increase in body weight gain and improve feed efficiency (FCR). However, some feed additives like hormones, probiotics, antibiotics and others have residual effect. They leave their residue in meat and egg. Among all these, probiotics are better for feeding of poultry to improve weight gain, feed efficiency and feed intake.

The term "probiotic" (a Greek word meaning "for life") was first of all used by Parker (1974) and he described it as 'the organisms and substances that contribute to intestinal microbial balance'. Fuller (1989) redefined it as 'a live microbial feed supplement that beneficially affects the host animal by improving intestinal microbial balance'. Thus, the probiotic culture includes strains of lactic acid bacteria (*Lactobacillus* and *Streptococcus*) and Bacillus *substilis,* Bifidobacterium, *Aspergillus oryzae*, yeast (*Saccharomyces cerevisiae*), Torulopsis (Panda, 2002).

Indian rural poultry farming by developing and releasing a synthetic colored dual-purpose strain namely "GIRIR-AJA". Symbolically expressed, Giriraja stands for king of the jungle fowl. It is a strain bred to resemble local fowls. Sturdy and resistant, it can easily acclimatize itself to any region and weather. Giriraja yields high quality and quantity of meat and eggs which can survive like any native stock, except for the routine rank. In other word, Giriraja is a miracle fowl.

The dietary use of probiotics is gaining momentum/popularity in recent past to counteract the stress because of their beneficial effects on live weight gain, feed conversion efficiency, reduced mortality (Panda, 2002; Upendra and Yathiraj, 2003). Hence the present

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investigation was planned to find out the effect of supplementation of probiotics on Feed conversion efficiency, dressing percentage and economics of rearing of Giriraja poultry birds.

MATERIAL AND METHODS

The present research work was planned to studies on "Supplementation of probiotics on growth performance of Giriraja poultry birds." Present study was carried out in Dept of Animal Husbandry and Dairy Science, Dr.PDKV Akola and Dept. of Poultry Science, Post Graduate Institute of Veterinary and Animal Sciences, Akola, during the year 2015-16 (MAFSU). The probiotics was procured from local market of Akola as feed additives for conducting the feeding trial on Giriraja bird. 90 chicks of day old age, belongs to Giriraja breed were procured from Government Hatcheries, Tapovan Amravati (Maharashtra). Experimental chicks were weighed and distributed randomly in to three treatment groups *viz*, T_1, T_2 and T_3 with 30 chicks in each group, on equal weight basis. The birds were randomly divided into five replicate groups of each treatment and the chicks were housed in separate compartments.

All the chicks were fed with ground maize for first two days of age. For the experiment, a commercial Starter (0-3 weeks) and finisher (4-6 weeks) crumbles were used during experimental period of 6 weeks. Fresh, clean and cool drinking water was provided to the experimental bird's *ad-libitum*. All the precautionary measures against diseases were taken throughout the experimental period of eight weeks. The dietary treatments were as followed as, T_1 (Standard ration), T_2 (Standard ration + 0.10% probiotic) and T_3 (Standard ration + 0.15% probiotic). The diets were fed *ad-libutum* to experimental birds by adding probiotics as given above.

Observations recorded

The experimental chicks were weighted individually at weekly interval up to the seven weeks using electronic balance. Weekly feed consumption was calculated by the amount of feed offered at the beginning of week, minus left over at the end of week and cumulative feed consumption was worked out for all the treatment groups. Weekly feed efficiency was calculated by using following formula-

$$FE = \frac{\text{Feed consumption (g) during the week}}{\text{Gain in body weight (g) during the week}}$$

Dressing percentage for all the treatment groups was calculated by slaughtering three birds from each treatment groups.The economics of Giriraja poultry rearing was worked out by considering the total cost of production which included the feed cost, chicks, labour, medicines, vaccines and the overhead costs The data on feed consumption, water intake and weekly body weights, was analyzed by Completely Randomized Designs described by Amble (1975)

RESULTS AND DISCUSSION

Weekly feed efficiency of Giriraja poultry birds:

The data recorded on average weekly feed conversion ratio was calculated, tabulated and presented in the Table 1.

The average weekly feed efficiency at seventh week age was 2.49, 2.26 and 2.14, in T_1, T_2 and T_3 treatments groups, respectively. The FCR was found to be statistically significant for different treatment groups during 2nd, 3rd, 4th, 5th, 6th and 7thweeks. Results recorded by some of research worker as discussed below were in agreement with present results.

Bai *et al.* (2013) investigated the effects of a probiotic product incorporating Lactobacillus fermentum, B. subtilis, B. licheniformis and Saccharomyces cerevisiae on the growth performance and intestinal immune status

Table 1. Weekly feed efficiency of Giriraja Birds

Treatment	1st week	2nd week	3rd week	4th week	5thweek	6th week	7thweek	Treatmentmean
T_1	1.13	1.38	1.72	1.56	2.06	2.30	2.49	1.81
T_2	1.13	1.38	1.68	1.78	1.91	2.12	2.26	1.76
T_3	1.07	1.36	1.52	1.66	1.79	2.00	2.14	1.65
Weekmean	1.11	1.37	1.64	1.67	1.92	2.14	2.30	
'F' test	NS	S						
SE(m)±	0.0255	0.0119	0.0073	0.1982	0.0038	0.004	0.0032	
CD	0.0785	0.0368	0.0225	0.6108	0.0118	0.0123	0.0100	

in broiler chickens. They compared the probiotic diet compared with control, and were similar to the probiotic plus antibiotic treated group. Patel *et al.* (2015) conducted trial on two hundred and forty (n=240), day-old broiler chicks of strain 'cobb400' were divided equally into 3 groups of 80 chicks each in group to observe the effect of probiotics (Protexin) supplementation on growth performance and economics of feeding in broilers. Different dietary treatments were T_1– basal diet without probiotics supplementation (control), T_2–T_1 + probiotics supplementation (50 g/ton of feed) and T_3– T_1 + probiotics supplementation (100 g/ton of feed) and found that feed efficiency was significantly (Pd"0.01) improved with probiotics supplementation @100 g ton^{-1} of feed compared to control.

Cumulative feed efficiency of Giriraja poultry birds:

The data recorded on average cumulative feed efficiency for different dietary treatment groups from first to seventh week of groups was analyzed tabulated and presented in Table 2.

The cumulative feed efficiency of various groups T_1, T_2 and T_3 were 3.28, 2.81 and 2.66, respectively. The feed conversion ratio for both the supplementation of probiotics group was significantly improved than the control group. The Cumulative weekly feed efficiency was found to be statistically significant for different treatment groups during 2nd, 3rd, 4th, 5th, 6thand 7th weeks. Results recorded by some of research worker as discussed below were in agreement with present results.

Eltazi *et al.* (2014) conducted trial of response of broiler chicks to diets containing live yeast as probiotic natural feed additive. the treatment group (A), fed on basal diet without feed additive (control group). The other groups B, C and D were fed on basal diet supplemented with yeast (Sc) at levels of 0.1, 0.2 and 0.3% respectively. The experimental diets were fed for 7-weeks duration. The result indicated that, the yeast (Sc) supplemented groups had significantly (P<0.05) better feed conversion ratio than the control group, chicks in group B, C and D produced significantly (P<0.05) better feed conversion ratio as compared to group A.

Naik *et al.* (2014) conducted experiment at poultry farm, Bheemarayanagudi using 90 day old Giriraja chicks, The two treatment groups T_1: control with synthetic methionine without Methionine producing probiotics, T_2: with Methionine producing probiotics without synthetic methionine and results found that cumulative feed conversion ratio varied non significantly (P>0.05) from 1.86 (T_2) to 2.06 (T_1). Probiotics supplemented diets showed increased body weight gains and decreased feed consumption, therefore the feed efficiency was better in probiotics supplemented diets.

Dressing percentage of Giriraja Poultry Birds

Dressing percentage for all the treatment groups was calculated by slaughtering three birds from each treatment groups. The dressing percentage was analyzed tabulated and presented in Table 3.

Table 3. Mean values of dressing percentage of Giriraja Poultry Birds

Treatments	Mean dressing percentage
T_1	59.54
T_2	63.30
T_3	65.77
'F' test	S
SE(m)±	0.43352
CD	1.33582

The average dressing percentage among the different treatment groups was recorded as 59.54, 63.30 and 65.77 per cent for treatment T_1, T_2 and T_3, respected. The effect of probiotics feeding on dressing percentage

Table 2. Cumulative feed efficiency of Giriraja Birds

Treatment	1st week	2nd week	3rd week	4th week	5thweek	6th week	7thweek	Treatmentmean
T_1	1.13	1.54	2.10	2.24	2.48	3.08	3.28	2.26
T_2	1.13	1.50	2.01	1.93	2.24	2.82	2.81	2.06
T_3	1.07	1.24	1.67	1.92	2.14	2.69	2.66	1.91
Weekmean	1.11	1.43	1.92	2.03	2.29	2.86	2.92	
'F' test	NS	S						
SE(m)±	0.0255	0.0127	0.0087	0.0119	0.0092	0.0147	0.0196	
CD	0.0785	0.0392	0.0269	0.0367	0.0283	0.0453		0.0604

was found beneficial which effect positively on dressing percentage. Results recorded by some of research worker as discussed below were in agreement with present results.

Saiyed *et al.* (2015) Studed on inclusion of probiotic, prebiotic and its combination in broiler diet and their effect on carcass characteristics and economics of commercial broilers. Day-old commercial broiler chicks (n=200) were distributed randomly into 5 dietary treatment groups viz. control (T_1), probiotic in the feed @ 100 g tonne^{-1} of feed (T_2), prebiotic in the feed @ 500 g tonne^{-1} of feed (T_3), probiotic + prebiotic @ 100 g tonne^{-1} and 500 g tonne^{-1} of feed, respectively (T_4) and probiotic + prebiotic @ 50 g tonne^{-1} and 250 g tonne^{-1} of feed (T_5). and found that among all carcass traits, dressing percentage, abdominal fat weight and abdominal fat percentage (as a percentage of dressed weight) were recorded significant ($p<0.05$) difference among different treatment groups.

Nawaz *et al.* (2016) conducted trial on effect of probiotics on growth performance, nutrient digestibility and carcass characteristics in broilers and results showed that the significantly ($P<0.05$) higher dressing percentage was found for birds fed diet supplemented with yeast @ 0.2 per cent followed by those fed diet supplemented with both (yeast 0.1% + Toyocerine® 0.1%) and those fed diet supplemented with Toyocerine® @ 0.2 per cent. Whereas, the birds fed control diet showed the minimum dressing percentage.

Economics of Giriraja poultry birds rearing

The economics of Giriraja poultry bird rearing was estimated by considering the total amount of feed consumed by birds under T_1, T_2 and T_3 treatments groups and other inputs such as cost of day old chicks, probiotics powder as feed additive, medicine, vaccines, litter material etc. However, the costs of labors, electricity, etc. were not considered in calculating the economics of Giriraja poultry bird production being post graduate research work. The data on economics is presented in Table 4.

It is revealed from the data of Table 4, that the cost of feed in T_2 and T_3 was increased in accordance with the level of addition of probiotics. Moreover, Giriraja poultry bird in treatment groups T_3 gained highest body weight (1.305 kg) with feed cost (Rs. 92.34) and control group gained weight (1.095kg) with feed cost (Rs.81.09). The net profit per bird was highest in T_3 (Rs.140.16) followed by T_2 (Rs.126.72) and lower in T_1 (Rs.109.41) as indicated in table 4. Results recorded by some of research worker as discussed below were in agreement with present results.

Eltazi *et. al.* (2014) conducted trial on the effect of feeding broiler chicks on diet containing different levels of backer's yeast saccharomyces cerevisiae (Sc) as probiotic natural feed additive on performance, carcass quality and economic efficiency was studied and found that, supplementation of dietary (Sc) improved the performance of broiler chicks and recorded economical benefit. Profitability ratio (1.12) of groups 0.3 per cent yeast (Sc) was the highest of the test groups. Naik *et al.* (2014) conducted experiment at poultry farm, Bheemarayanagudi using 90 day old Giriraja chicks, The two treatment groups T_1: control with synthetic

Table 4. Economics of Giriraja Poultry Birds rearing

S.N.	Particulars	T_1	T_2	T_3
1.	Cost of day old chick (Rs. 21.5 / chicks)	21.50	21.50	21.50
2.	Cost of feed (Rs/kg or 1530 Rs / 50 kg bags)	30.60	30.60	30.60
3.	Cost of probiotics (Rs 1000/500 g)	0.00	2.00	4.00
4.	Total cost of feed (Rs/kg)	30.60	32.60	34.60
5.	Average total feed consumed per bird (Kg)	2.650	2.662	2.669
6.	Cost of feed consumed per bird (Rs.)	81.09	86.78	92.34
7.	Average body weight at the end of 7th week (Kg)	1.095	1.210	1.305
8.	Feed consumption per kg live weight gain (Kg)	2.420	2.200	2.045
9.	Cost of feed per kg live weight gain (Rs.)	74.05	72.16	70.75
10.	Rearing Cost per bird (Rs.)	7.00	7.00	7.00
11.	Total cost of production (Rs.) (1+6+10)	109.59	115.28	120.84
12.	Average price realized @ Rs. 200 per kg live weight (Rs.)	219.00	242.00	261.00
13.	Net profit per bird (Rs.) (12-11)	109.41	126.72	140.16

methionine without Methionine producing probiotics, T_2: with Methionine producing probiotics without synthetic methionine and results found that net returns was statistically significant ($P<0.05$) and net returns varies from Rupees 36.16 (T_1) to Rupees 45.80 (T_2) per chick. Feeding of methionine producing probiotics has improved body weight gains, reduced feed consumption and improved livability, which has contributed for the better net returns. Patel *et al.* (2015) studied on two hundred and forty (n=240), day-old broiler chicks of strain 'cobb400' were divided equally into 3 groups of 80 chicks each in group to observe the effect of probiotics (Protexin) supplementation on economics of feeding in broilers. The return over feed cost was significantly (Pd"0.01) higher in T_2 (Rs. 30.99) as compared to T_1 (Rs. 27.82) and control (Rs. 26.45). The profit per bird over control in group T_2 and T_3 was (Rs. 1.37) and (Rs. 4.54) respectively.

CONCLUSION

From the present investigation it is concluded that, the cumulative feed efficiency of various groups T_1, T_2 and T_3 were 3.28, 2.81 and 2.66, respectively. While, the Cumulative weekly feed efficiency was found to be statistically significant for different treatment groups during 2nd, 3rd, 4th, 5th, 6thand 7th weeks. The average dressing percentage among the different treatment groups was recorded as 59.54, 63.30 and 65.77 percent for treatment T_1, T_2 and T_3, respected. The net profit per bird was highest in T_3 (Rs.140.16) followed by T_2 (126.72) and lower in T_1 (Rs.109.41). The effect of probiotics feeding on dressing percentage was found beneficial which effect positively on dressing percentage.

Hence, supplementation of 0.15% probiotics is found beneficial to improve the feed conversion efficiency, dressing percentage and net profit of Giriraja poultry birds.

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Techo-economic Feasibility of Orange (*Citrus reticulate)* Juice based Paneer Whey Beverage

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ABSTRACT

The present investigation was undertaken during 2015-16 at the department of Animal Husbandry and Dairy Science and Department of Plant Pathology, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra. Whey is the largest and highly nutritious important by product of the dairy industry, it is obtained during the manufacture of casein, cheese, paneer, channa and shrikhand. The conversion of whey into beverage is one of the most attractive avenues for utilizing whey for human consumption. The paneer whey beverage was prepared by using different levels of orange juice @ 10, 15, 20, 25 and 30 per cent with 8 per cent sugar. From the present investigation it is concluded that the paneer whey can very well be utilized for preparation of acceptable whey beverage. The overall acceptability of paneer whey beverage blended with 25 per cent orange juice was significantly superior and more acceptable than other levels of orange juice. The running cost of production of orange based paneer whey beverage product calculated as Rs. 11.57 to 21.47 lit^{-1}.

Whey is a nutritious by product obtained from cheese, *Chhana* and *Paneer* containing valuable nutrients like lactose, proteins, minerals and vitamins etc., which have indispensable value as human food. In India about 3 million tonnes of whey is produced annually containing about 2 lakh tonnes of valuable milk nutrients, the *chhana* and *paneer whey* give the major contribution (about 80 per cent) in total whey production (Naik *et al.* 2009). Whey possesses preventive and curative elements and is especially used to trait a wide variety of ailments such as arthritis, anemia and liver complaints. Whey drinks can stabilize the osmolar system in the body and have a thirst quenching effect. Whey proteins also have special reference to biological activities, against HIV infection, immune system, stimulation and therapeutic value (Bajaj and Sangwan, 2002). Whey is a serious source of environmental pollution in Indian dairy industry because of high Biological Oxygen Demand (BOD) value ranging from 39,000 to 48,000 ppm (Divya and Kumari, 2009). Utilization of whey protein for the preparation of geriatric foods represents a promising avenue for new product development.

Orange fortified with paneer whey beverage is popular and cheaply available beverage, it protects against different vitamin deficiency disease, it is beneficial for health in many ways. Oranges constitute a significant source of antioxidants (mainly vitamin C), polyphenol compounds (hydroxyl cinnamic acid and flavanones), phyto-chemicals (hesperidins and narigenin) and various vitamins and minerals. These components exhibit therapeutic properties such as anti-inflammatory, antihypertensive, diuretic, analgesic and hypolipidemic activities (Klimczak *et al.*, 2007). Nutritive benefits of whey can be utilized with fruit juice, pulp or concentrate in the development of a value added beverage. This would be the most logical and economical way of utilization of whey nutrients in human food chain (Goyal and Gandhi, 2009). In order to make the use of whey, present study is contemplated by supplementing with orange Juice.

MATERIAL AND METHODS

Good quality fresh buffalo milk was procured and then strained through muslin cloth. The fat content in milk ranged from 6 per cent. The milk was transferred to stainless steel vessel and heated to about 90°C. The vessel was then removed from the fire and cooled to 72°C. The coagulant *i.e.* citric acid solution @ 1.5 per cent was added slowly till complete coagulation of milk. Then the mass was poured over stretched piece of clean muslin cloth over another vessel to drain the whey. The clear drained whey was collected in the vessel. The yellowish green whey was then used for the preparation of whey beverage. After getting whey 8 per cent sugar and Orange juice were added. The products were filled in sterilized bottles and then cooled and stored in refrigerator at 5-7°C.

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Preparation of paneer whey beverage

Paneer Whey

↓

Addition of sugar (8%)

↓

Addition of orange juice (as per treat.)

↓

Addition of stabilizer (0.1%)

(Sodium citrate)

↓

Mixing

↓

Bottling

↓

Refrigerated cooling (5-7°C) and storage

(Reddy *et al.*, 1987)

Treatment details:

For preparing the RTS beverages, whey and orange juice were blended in different ratios. Five blends with different dilutions were prepared as shown in Table 1.

Table.1 : Composition of various whey based orange juice beverage

Treatments	Whey (%)	Orange(%)
T_1	90	10
T_2	85	15
T_3	80	20
T_4	75	25
T_5	70	30

Sugar level kept constant *i.e.* @ 8 % (w/v) of final product.

The product so obtained was subjected to sensory evaluation by the panel of judges. It was evaluated for flavour, colour and appearance, consistency and overall acceptability on 9-point hedonic scale (Gupta, 1976 and BIS, 1971). Cost structure of paneer whey beverage was calculated as per prevailing rates of all ingredients used for the preparation of beverage. Cost of paneer whey was taken as Rs. 0.50 lit^{-1}. This cost was applied by the various research workers. The cost of orange juice was Rs. 50 $lit.^{-1}$ and the cost of sugar was Rs. 39/Kg. The obtained data were analyzed by Randomized Block Design with five treatments and four replications as per the method given by Panse and Sukhatme (1967).

RESULTS AND DISCUSSION

The result obtained from the present investigation are presented in Table 2.

Table 2. Chemical composition of paneer whey

Constituent per cent				
Fat	**Protein**	**Reducing Sugar**	**Acidity**	**pH**
0.48	0.47	4.43	0.18	5.32

The average chemical composition of paneer whey utilized for whey beverage preparation contain fat 0.48 per cent, protein 0.47 per cent, reducing sugar 4.43 per cent, 0.18 per cent acidity and pH 5.32.(Table 2).The values for different paneer whey were within the normal range as reported by Saravankumar and Manimegalai (2002) reported that, paneer whey contained 7 per cent solids, 0.1 per cent acidity, 5.2 pH and 5.2 per cent total sugar.

Table 3. Chemical composition of orange juice

Constituent per cent				
TSS	**Reducing Sugar**	**Total sugar**	**Acidity**	**pH**
9.13	2.24	6.46	0.69	4.35

The orange juice contains TSS (°Brix) 9.13, reducing sugar 2.24 per cent, total sugar 6.46 per cent, acidity 0.69 and pH 4.35. (Table 3). These contention was supportive to the results reported by Chatterjee et al. (2015) reported physic-chemical characteristics of orange juice and obtained that it is reach in vitamin C content. The total soluble solids in fruit 9.13 $\pm$0.21%, reducing sugar 2.24 $\pm$ 0.36%, total sugar 6.46 $\pm$ 0.07, titrable acidity 0.69 $\pm$ 0.023 and pH 4.35 $\pm$0.04.

Cost structure of paneer whey beverage :

The cost of production of one litre paneer whey beverage was calculated by taking into account the prevailing markets rates of various inputs viz., paneer whey, orange juice, sugar, while the other charges such as fuel and labour etc were worked out on the basis of actual

Table 4: Estimated cost structure of paneer whey beverage (Rs/lit)

S. N.	Particular	Treatment combinations									
		T_1		T_2		T_3		T_4		T_5	
		Qty. (g)	Amount (Rs.)	Qty. (g)	Amount (Rs.)	Qty. (g)	Amount (Rs.)	Qty. (g)	Amount (Rs.)	Qty. (g)	Amount (Rs.)
1	Whey (ml) (0.50 Rs/lit)	900	0.45	850	0.42	800	0.40	750	0.37	700	0.35
2	Orange juice (50 Rs/lit)	100	5.00	150	7.50	200	10.00	250	12.50	300	15.00
3	Sugar @ 8% (39 Rs/kg)	80	3.12	80	3.12	80	3.12	80	3.12	80	3.12
4	Sodium citrate (0.1%)	1	1	1	1	1	1	1	1	1	1
5	Other (fuel, labour, mis cellaneous)	_	2	_	2	_	2	_	2	_	2
6	Total cost (Rs/lit)	—	11.57	—	14.04	—	16.52	—	18.99	—	21.47
7	Cost /200 ml (Rs/200 ml)	—	2.11	—	2.60	—	3.10	—	3.59	—	4.09

hours of the work performed for the preparation of one litre paneer whey beverage. (Table 4).

The data presented in Table 4 indicated that the cost of paneer whey beverage with different levels of orange juice ranged between Rs. 11.57 to Rs. 21.47 per 1000 ml for treatment T_1 to T_5 respectively. The cost of treatment T_2, T_3 and T_4 was 14.04, 16.52 and 18.99 per 1000 ml, respectively. The highest cost was recorded for treatment T_5 i.e. Rs. 21.47 where in 30 per cent orange juice was incorporated. The lowest cost was recorded for treatment T_1 i.e. Rs. 11.57. Increased level of orange juice showed the increasing trend in cost of production of paneer whey beverage. However, a superior treatment selected by the panel of judges on the basis of sensory evaluation was T_4 with 25 per cent orange juice costing Rs. 18.99/lit. The cost of production of paneer whey beverage in best treatment was somewhat more than the other treatment. Based on 200 ml beverage bottle, the cost of production of treatment T_4 was only Rs.3.79, which seems to be very cheaper as compared to different soft drinks or beverages sold in market. Results obtained are in agreement with Raut (2007) and Bothe (2013) opined that the cost of production of chhana whey orange based beverage and whey based mango herbal beverage increase with increase in level of blending of orange and lemongrass extract in the beverage.

CONCLUSION

Whey a by-product generated during manufacturing of paneer can be efficiently utilized for the preparation of whey beverage products. The manufacturing cost of orange based paneer whey beverage product calculated on the basis of prevailing market rates of ingredients, was laid in the range of Rs. 11.57 to 21.47/ lit. Increased level of orange juice showed the increasing trend in cost of production of paneer whey beverage. The cost of production of best treatment on the basis on sensory evaluation (T4) was Rs. 18.99/ lit.

Based on 200 ml beverage bottle the cost of production of treatment T4 was only Rs. 3.59, which seems to be very cheaper as compared to different soft drinks or beverages sold in the market. The technology standardized under present study provides pace for household and commercialization at industrial level.

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RESEARCH NOTES

Optimization of Spacing and Fertilizer Dose for Chickpea cv. PDKV Kanchan

Among various agronomic factors limiting yield, planting pattern is considered of great importance. Increase in yield can be ensured by maintaining appropriate plant population through different planting patterns. Too low and high plant population beyond a certain limit often adversely affects the crop yield. Seed yield and yield parameters of mungbean were affected significantly by different planting patterns and maximum seed yield was obtained in 30 cm apart rows (Ali *et al.*, 2001).Muchow (1985) examined the competitive response of range of legumes to soil moisture regimes and reported that grain legumes varied significantly from each other in term of phenology and yield. Number of plants per unit area influences plant size, yield components and ultimately the seed yield (Beech and Leach, 1989). Moreover, plant spacing in the field is also very important to facilitate aeration and light interception in to plant canopy for optimizing rate of photosynthesis. There is very little information available on the relative contribution of various plant spacing towards yield and yield components and also their interaction. Panwar *et al.* (1980) reported row spacing of 45 cm increased chickpea yield compared to 30 and 50 cm spacing while Parihar (1996) indicated that row spacing had no significant effect on seed yield. Keeping this in view the present study was initiated to find out suitable planting pattern for chickpea to obtain maximum yield in Vidarbha under irrigated conditions.

A field experiment to determine the comparative production potential of different grain legumes namelychickpea under different planting patterns i.e. sowing in 30x10 cm and 45x10 cm with four levels of fertilizers i.e. Absolute control, 20:40:00 kg NPKha^{-1}, 25:50:00 kg NPKha^{-1} and 30:60:00 kg NPKha^{-1} was conducted at the Pulses Research Unit, Dr.Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *rabi* 2015-16. The experiment was laid out in factorial randomized complete block design (FRBD) having three replications. The net plot size was 3.6 x 4.0 m. All the crops were sown on November 09, 2015 using uniform seed rate of 60 kg/ha. A basal dose of fertilizer was applied in the form of Urea and di-ammonium phosphate, respectively, uniform 30 kg K_2O ha^{-1} was applied to 100% and 125% RDF level. All other agronomic practices were kept normal and uniform for all the treatments. The data on growth yield and quality parameters of all the crops were recorded following the standard procedure.

A perusal of Table 1 showed significantly higher grain yield with closer spacing of 30x10 cm over wider spacing of 45x10 cm due to the highest number of plants m^{-2} and therefore more number of pods plant^{-1} as compared to wider spacing. Singh *et al.* (1991) reported that narrow spacing resulted in higher grain yields in food legumes. Number of pods per plant was affected significantly by different planting patterns. The 45x10cm spacing produced more number of pods per plant than 30x10 cm spacing in chickpea. Higher number of pods per plant might have been due to efficient interception of light and utilization of available resources. A significant effect of planting geometry on number of pods per plant has been reported by Ali *et al.* (2001). The test weight was statistically at par due to different spacing. The variation in test weight of different legumes might be due to a genetic make genotype. The results are similar to those of Qamar and Malik (1999).Among fertilizer levels grain yield, plant height, branches plant^{-1}, pods plant^{-1} grain weight plant^{-1} and test weight were significantly influenced over control. However, higher grain yield was recorded with the application of 30:60:30 kg N:P_2O_5:K_2O ha^{-1} followed by 25:50:30 kg N:P_2O_5:K_2O ha^{-1} which in turn recorded significantly higher grain yield over control. The similar result was reported by Ali *et al.* (2001). On the basis ofnet return obtained with different spacing did not influenced significantly, however, among fertilizer levels application of 30:60:30 kg N:P_2O_5:K_2O ha^{-1} recorded significantly higher returns over remaining treatments and net return observed with the application of25:50:30 kg N:P_2O_5:K_2O ha^{-1}was found at par with absolute control. Interaction between spacing and fertilizer did not influence significantly.

It is concluded that both spacing of30x10 cm or 45x10 cm with application of 30:60:30 kg N:P_2O_5:K_2O ha^{-1}are advantageous for chickpea cultivar PDKV Kanchan.

Table 1: Effect of different treatment on growth parameters, yield and economics of chickpea

Treatment	Grain yield (kg ha^{-1})	Plant ht(cm)	Branches plant^{-1}	Pods plant^{-1}	Grain wt. plant^{-1} (g)	100-seed wt(g)	Cost of cultivation (Rs ha^{-1})	GMR (Rs ha^{-1})	NMR (Rs ha^{-1})	BCR
Factor A. Spacing										
30 x 10 cm	1674	27.5	5.9	57.4	9.8	16.4	21697	58594	36897	2.70
45 x 10 cm	1535	40.4	6.7	64.3	12.0	16.7	21446	53723	32277	2.50
CD at 5%	100.0	1.53	0.18	1.89	0.58	NS	—	4569	4569	—
Factor B. Fertilizer levels										
Absolute control	1400	37.2	5.6	54.2	8.5	15.6	18708	48967	30259	2.61
100% RDF (25:50:30 kg N:P_2O_5:K_2O ha^{-1})	1599	41.7	6.3	62.0	11.2	16.8	22519	55955	33436	2.48
125% RDF (30:60:30 kg N:P_2O_5:K_2Oha^{-1})	1816	44.2	6.9	66.3	13.1	17.3	23487	63553	40066	2.70
CD at 5%	122.5	1.87	0.22	2.31	0.71	0.43	—	5596	5596	—

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Effect of Zinc Application on Yield and Uptake of Nutrients by Sorghum (*Sorghum bicolor*) Genotypes

Sorghum is tolerant to drought, well adapted to the semi-arid and arid climate condition of Africa and Asia. It is an important staple food for millions of poor people. Sorghum is an exhaustive crop and its requirement for nutrients especially for nitrogen is high. Besides nitrogen, phosphorus, potassium, secondary nutrients and micronutrients are necessary for increasing grain yield of sorghum.

Zinc is essential for several enzyme systems that regulate vital metabolic reaction in the plant body. It is essential for auxin production in plant. It is also required for synthesis of tryptophan which in turn may be precursor of IAA. It is helpful in reproduction of certain plants and required for normal plant growth. It is constituent of carbonic anhydrase, alcoholic dehydrogenase, superoxide dismutase. Zinc is involved in the synthesis of indole acetic acid, metabolism of gibberellic acid and synthesis of RNA. Its preferential binding to sulphydryl group influences translocation and transport of phosphorus in plants.

Zinc deficiency is responsible for many severe health complications, including impairments of physical growth, immune system and learning ability, combined with increased risk of infections, DNA damage and cancer development. The zinc deficiency is currently listed as fifth major risk factor for human health and cause of death globally. The deficiency symptoms of Zn are interveinal chlorosis, first appearing on the young leaves, reduction in the size of young leaves, which are often clustered or borne very closely, bronzing in plants. In crops like wheat (*Triticum aestivum*) grain Fe and Zn concentration can be increased by application of micronutrient fertilizers (Cakmak, 2008), which is termed as agronomic fortification or fertifortification. The attempt was made in sorghum, with the soil and foliar application of zinc.

In view of the above, experiment was conducted in split plot design with main plot treatment (sorghum genotypes) and sub plot treatment (zinc levels) in three replications during *kharif season* 2014-15 at Dr. PDKV, Akola. Sorghum genotypes G_1: CSH-35, G_2: PVK-809, G_3 : CSV-20, G_4 : AKSV-181, G_5 : AKSV-161, G_6 : AKSV-313, G_7 : AKSV-314 and G_8 : AKSV-318 were selected to study the Zn application on yield and uptake by sorghum in black soil. The zinc treatments comprised of Z_1- No Zn application, Z2- Soil application of Zn @ 5 kg ha^{-1} through $ZnSO_4$ at the time of sowing, Z3- Soil application of Zn @ 5 kg ha^{-1} through $ZnSO_4$ with two foliar sprays before flowering and at dough stage of $ZnSO_4$ @ 0.5 %. Recommended dose of NPK (80:40:40 kg ha^{-1} N, P_2O_5 and K_2O) was applied in all treatments. The soil was low in available nitrogen (219.78 kg ha^{-1}) medium available in phosphorus (22.25 kg ha^{-1}) high in available potassium (392.00 kg ha^{-1}) and deficient in DTPA- Zn (0.58 mg kg^{-1}). The soil analysis was carried out following standard methods. Plant samples were processed following standard procedure of threshing, drying and grinding. Grain, leaves, stem and root samples (0.5 g) was digested with di-acid (HNO_3 : $HCLO_4$ in 9:4) (Piper 1966).

Grain and dry matter yield

The sorghum genotype CSH-35 recorded significantly highest grain yield (39.87 q ha^{-1}) as compared to all genotypes and followed by AKSV-181 (31.13 q ha^{-1}). The yield of sorghum leaves was registered significantly highest in AKSV-161 (38.96 q ha^{-1}) as compared to rest of genotypes but on par with that of AKSV-181 and PVK-809 (Table 1). Stem dry matter yield was noticed significantly highest in AKSV-161 (80.06 q ha^{-1}) while lowest stem yield (62.35 q ha^{-1}) was recorded in CSH-35. The genotypes AKSV-161 recorded significantly highest root dry matter yield (27.15 q ha^{-1}) as compared to the other genotypes. The total dry matter yield was registered by AKSV-161 (176.66 q ha^{-1}) as compared to rest of the genotypes and found at par with AKSV-181 (176.54 q ha^{-1}), PVK-809 (169.10 q ha^{-1}) and AKSV-313 (165.82 q ha^{-1}).

The significantly highest grain yield (32.54 q ha^{-1}), leaves dry matter (38.73 q ha^{-1}), stem dry matter (79.20 q ha^{-1}), which showed 16 per cent higher over the control and root dry matter yield (26.90 q ha^{-1}) and total dry matter yield (177.76 q ha^{-1}) was recorded with soil application of Zn @ 5 kg ha^{-1} through $ZnSO_4$ along with two foliar sprays before flowering and at dough stage of $ZnSO_4$ @ 0.5 % and followed by soil application of 5 kg Zn ha^{-1} through $ZnSO_4$ (31.52 q ha^{-1}). The soil application of Zn @ 5 kg ha^{-1} and two foliar spray of $ZnSO_4$ @ 0.5 % increased grain yield by 3.24 per cent over soil application of Zn @ 5 kg ha^{-1} and 7.32 % over control (Table 1). Cakmak (2008) reported highest increase in grain yield with soil and soil + foliar application of Zn. Soleymani

Table 1. Yield of sorghum genotypes as influenced by zinc levels

Treatment	Yield (q ha^{-1})				
	Grain	Leaves	Stem	Root	Total dry matter
A) Main plot (Genotypes)					
G_1 : CSH-35	39.87	31.07	62.35	19.25	152.53
G_2 : PVK-809	30.49	37.02	75.81	25.78	169.10
G_3 : CSV-20	30.42	36.30	73.75	24.14	164.60
G_4 : AKSV-181	31.13	38.89	79.52	27.00	176.54
G_5 : AKSV-161	30.49	38.96	80.06	27.15	176.66
G_6 : AKSV-313	29.76	36.47	74.86	24.73	165.82
G_7 : AKSV-314	29.36	36.55	73.21	24.43	163.56
G_8 : AKSV-318	30.17	34.76	71.74	23.25	159.91
SE(m)±	0.62	0.74	2.10	0.88	3.59
CD at 5%	1.90	2.24	6.36	2.66	10.88
B) Sub-plot (Zinc levels)					
Z_0 - Control	30.32	33.50	68.23	21.89	153.94
Z_1 - SA	31.52	36.53	74.31	24.61	166.97
Z_2 - FS	32.54	38.73	79.20	26.90	177.36
SE(m)±	0.15	0.33	0.82	0.34	1.38
CD at 5%	0.42	0.96	2.36	0.99	3.98
C) Interaction (A x B)					
SE(m)±	0.41	0.94	2.31	0.97	3.91
CD at 5%	1.18	NS	NS	NS	NS

Z_0: Control, **Z_1** : SA of 5 kg Zn ha^{-1} through $ZnSO_4$, **Z_2** :SA of 5 kg Zn ha^{-1} through $ZnSO_4$ + Two FS before flowering and at dough stage of $ZnSO_4$ @ 0.5 %

Table 1a. Interaction effect between sorghum genotypes and zinc levels of grain yield in Vertisols

Genotypes	Zinc levels			
	Z_0	Z_1	Z_2	Mean
G_1 : CSH-35	39.21	39.92	40.48	39.87
G_2 : PVK-809	29.04	30.26	32.16	30.49
G_3 : CSV-20	29.27	29.98	32.01	30.42
G_4 : AKSV-181	29.09	31.79	32.51	31.13
G_5 : AKSV-161	29.92	30.52	31.04	30.49
G_6 : AKSV-313	28.86	30.44	29.97	29.76
G_7 : AKSV-314	28.24	29.51	30.34	29.36
G_8 : AKSV-318	28.95	29.77	31.79	30.17
Mean	30.32	31.52	32.54	31.46
SE(m)±	0.41			
CD at 5%	1.18			

and Shahrajabian (2012) noticed foliar application of Zn increased leaves and stem dry yield of sorghum.

Significantly highest grain yield (40.48 q ha^{-1}) was recorded in CSH-35 in combination with soil application of 5 kg Zn ha^{-1} and two foliar sprays before flowering and at dough stage of $ZnSO_4$ @ 0.5 % (Table 2). This could be attributed to high yield potential and response to application of zinc through soil and foliar.

Nitrogen, Phosphorus and Potassium content and uptake

The higher content of nitrogen (1.63 to 1.80 %) was recorded in grains of sorghum genotypes while

in content of potassium was registered in leaves (1.24 to 1.44 %) and stem (1.48 to 1.65 %) (Table 2). The highest content of N, P and K were recorded in CSH-5 genotype in grains. Significantly higher nitrogen uptake by grain was recorded in the CSH-35 (71.55 kg ha^{-1}) as compared to the rest of genotypes. This could be attributed to the genetic variability of genotypes. Significantly highest nitrogen content 0.94 % in leaves was recorded by CSH-35 while higher nitrogen uptake by leaves recorded in AKSV-161 (34.43 kg ha^{-1}) which was superior over other genotypes. AKSV-161 recorded significantly highest nitrogen content in stem (0.71 %) statistically superior to other genotypes and it was at par with AKSV-318 (0.68%) whereas significantly highest nitrogen uptake by stem was recorded in the AKSV-161 (52.78 kg ha^{-1}) which was at par with the PVK-809 (49.05 kg ha^{-1}), AKSV-318 (48.97 kg ha^{-1}) and AKSV-181 (48.70 kg ha^{-1}) (Table 3). This could be attributed to higher dry matter yield of grain, leaves, stem and root of sorghum.

Significantly highest phosphorus content (0.43 %) in grain was recorded by CSH-35 and AKSV-161 but at par with AKSV-313, CSV-20, AKSV-181 and AKSV-318 while highest phosphorus uptake by grain was noticed in CSH-35 (17.01 kg ha^{-1}) which was superior over all genotypes (Table 3). The highest total phosphorus uptake was recorded by AKSV-161(33.82 kg ha^{-1}) and at par with the CSH-35 (33.46 kg ha^{-1}) genotype.

Slightly higher potassium content in grain (0.63%), leaves (1.44%), stem (1.61%) and root (0.69%) were recorded by CSH-35 which was at par with AKSV-161, AKSV-314, AKSV-318, PVK-809 and AKSV-313. Whereas, highest total potassium uptake was recorded by AKSV-161 (215.23 kg ha^{-1}) which was found at par with the PVK-809 (204.66 kg ha^{-1}) and AKSV-181 (206.02 kg ha^{-1}).

Soil application of Zn @ 5 kg ha^{-1} with two foliar sprays before flowering and at dough stage of $ZnSO_4$ @ 0.5 % recorded significantly highest nitrogen content in grain (1.79 %) followed by soil application of Zn @ 5 kg ha^{-1} (1.75 %) and control (1.65 %) with 8.48 per cent increase in nitrogen content over control. Similarly, significantly higher nitrogen uptake (58.44 kg ha^{-1}) by sorghum grain was observed which increased 16.53 per cent nitrogen uptake by grain as compared to control while soil application of Zn @ 5 kg ha^{-1} increased nitrogen uptake by 10.22 per cent.

Significantly higher nitrogen content in leaves (0.86 %), in stem (0.68 %) and in root (0.86 %) were recorded with soil application of Zn @ 5 kg ha^{-1} with two foliar sprays of $ZnSO_4$ @ 0.5 % before flowering and at dough stage. The findings corroborates with the results reported by Mohammad *et al.* (2008) wherein they found that the foliar application of zinc increased N concentration in leaves. The soil application and foliar sprays also recorded significantly higher nitrogen uptake by leaves (33.32 kg ha^{-1}), by stem (53.66 kg ha^{-1}) and by root (23.00 kg ha^{-1}). The results are in line with Jadhao *et al.* (2002), they registered that application of 5 kg Zn ha^{-1} significantly increased N uptake in groundnut straw. The soil application of 5 kg Zn ha^{-1} with two foliar sprays before flowering and at dough stage of $ZnSO_4$ @ 0.5 % recorded higher total nitrogen uptake (168.41 kg ha^{-1}) followed by soil application of 5 kg Zn ha^{-1} (153.46 kg ha^{-1}) which was 24.73 per cent of total nitrogen uptake as compared to control while soil application of 5 kg Zn ha^{-1} increased total nitrogen uptake by 13.66 per cent (Table 3). The findings commensurate with results reported by Keram *et al.* (2012) wherein they found that total nitrogen uptake increased significantly with the application of Zn @ 20 kg ha^{-1} along with recommended NPK as compared to control.

The soil application of Zn @ 5 kg ha^{-1} recorded significantly highest phosphorus content in grain (0.40 %). However, further increasing the zinc level registered decrease in phosphorus content in grain due to antagonistic effect of zinc with phosphorus. The increasing zinc level from control to soil application of Zn @ 5 kg ha^{-1} enhanced phosphorus content (0.38 to 0.40 %) whereas soil application of Zn @ 5 kg ha^{-1} with two foliar sprays before flowering and at dough stage $ZnSO_4$ @ 0.5 % decreased phosphorus content (0.39 %) in grain. The results are inconformity with the finding reported by Savithri and Ramulu (1980) who found that the higher application of Zn along with NPK significantly reduced P content in grain of sorghum. Soil application of Zn @ 5 kg ha^{-1} recorded higher phosphorus uptake (12.76 kg ha^{-1}) which was at par with soil application and foliar sprays (12.59 kg ha^{-1}).

The soil application of Zn @ 5 kg ha^{-1} with two foliar sprays before flowering and at dough stage of $ZnSO_4$ @ 0.5 % significantly recorded highest phosphorus uptake (8.47 kg ha^{-1}) by leaves followed soil application of Zn @ 5 kg ha^{-1} (8.24 kg ha^{-1}) and control (6.93 kg ha^{-1}). The soil application of Zn @ 5 kg ha^{-1} only and soil application of Zn @ 5 kg ha^{-1} with two foliar sprays before flowering

Table 2. Nitrogen, Phosphorus and Potassium content by various parts of sorghum genotypes as influenced by zinc levels

Treatment	Nitrogen content (%)				Phosphorus content (%)				Potassium content (%)			
	Grain	Leaves	Stem	Root	Grain	Leaves	Stem	Root	Grain	Leaves	Stem	Root
G_1 : CSH-35	1.80	0.94	0.71	0.89	0.43	0.26	0.10	0.12	0.63	1.44	1.65	0.69
G_2 : PVK-809	1.71	0.81	0.64	0.79	0.35	0.21	0.09	0.11	0.57	1.37	1.58	0.66
G_3 : CSV-20	1.75	0.80	0.63	0.77	0.39	0.20	0.08	0.11	0.54	1.31	1.52	0.65
G_4 : AKSV-181	1.70	0.79	0.61	0.78	0.39	0.21	0.08	0.12	0.58	1.30	1.50	0.64
G_5 : AKSV-161	1.77	0.88	0.66	0.86	0.43	0.25	0.10	0.11	0.61	1.36	1.57	0.67
G_6 : AKSV-313	1.63	0.80	0.61	0.78	0.42	0.20	0.08	0.10	0.57	1.31	1.51	0.66
G_7 : AKSV-314	1.72	0.78	0.62	0.75	0.36	0.21	0.08	0.11	0.57	1.29	1.56	0.67
G_8 : AKSV-318	1.77	0.89	0.68	0.82	0.37	0.20	0.08	0.12	0.56	1.24	1.48	0.67
SE(m)±	0.03	0.012	0.009	0.01	0.018	0.01	0.005	0.002	0.0081	0.0178	0.0191	0.007
CD at 5%	0.092	0.037	0.028	0.029	0.053	0.029	0.015	0.007	0.0244	0.054	0.058	0.0212
B) Sub-plot (Zinc levels)												
Z_0 - Control	1.65	0.81	0.61	0.75	0.38	0.21	0.08	0.11	0.57	1.31	1.53	0.66
Z_1 - SA	1.75	0.84	0.65	0.80	0.40	0.23	0.09	0.11	0.58	1.33	1.55	0.67
Z_2 - FS	1.79	0.86	0.68	0.86	0.39	0.22	0.09	0.12	0.59	1.34	1.56	0.67
SE(m)±	0.009	0.004	0.003	0.005	0.004	0.001	0.001	0.002	0.0009	0.0022	0.002	0.002
CD at 5%	0.027	0.012	0.009	0.014	0.011	0.002	0.002	0.007	0.0027	0.0063	0.0056	0.0059
C) Interaction (A x B)												
SE(m)±	0.026	0.012	0.008	0.014	0.011	0.002	0.002	0.007	0.0027	0.0062	0.0055	0.0058
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 3. Nitrogen, Phosphorus and Potassium uptake in various parts of sorghum genotypes as influenced by zinc levels

Treatment	Uptake of Nitrogen (kg ha^{-1})					Uptake of Phosphorus (kg ha^{-1})					Uptake of potassium (kg ha^{-1})				
	Grain	Leaves	Stem	Root	Total	Grain	Leaves	Stem	Root	Total	Grain	Leaves	Stem	Root	Total
A) Main plot Genotypes)															
G_1 : CSH-35	71.55	29.31	44.17	17.17	162.2	17.01	8.01	6.17	2.27	33.46	25.01	44.87	103.2	13.23	186.31
G_2 : PVK-809	52.31	30.15	49.05	20.44	151.95	10.56	7.86	7.00	2.88	28.30	17.4	50.57	119.59	17.09	204.66
G_3 : CSV-20	53.36	28.96	46.57	18.53	147.43	11.68	7.21	5.79	2.77	27.45	16.49	47.64	112.47	15.7	192.3
G_4 : AKSV-181	53.08	30.89	48.7	21.22	153.89	12.00	8.33	6.24	3.17	29.75	18.16	50.79	119.63	17.44	206.02
G_5 : AKSV-161	53.9	34.43	52.78	23.42	164.53	13.05	9.71	7.99	3.07	33.82	18.49	53.03	125.4	18.32	215.23
G_6 : AKSV-313	48.72	29.35	45.49	19.43	142.99	12.39	7.36	6.07	2.55	28.37	16.84	47.86	113.15	16.37	194.23
G_7 : AKSV-314	50.58	28.55	45.37	18.31	142.81	10.59	7.53	5.72	2.78	26.63	16.8	47.14	114.42	16.49	194.84
G_8 : AKSV-318	53.49	30.98	48.97	19.1	152.54	11.17	7.05	5.84	2.72	26.78	16.85	43.13	106.44	15.58	182.0
SE(m)±	1.48	0.76	1.67	0.72	3.51	0.466	0.428	0.324	0.113	0.79	0.51	1.04	3.88	0.54	5.19
CD at 5%	4.49	2.3	5.07	2.18	10.66	1.413	1.298	0.983	0.344	2.41	1.56	3.14	11.76	1.64	15.74
B) Sub-plot (Zinc levels)															
Z_0 - Control	50.15	27.01	41.44	16.4	135.01	11.56	6.93	5.37	2.33	26.2	17.36	43.85	104.46	14.32	179.99
Z_1 - SA	55.28	30.65	47.82	19.7	153.46	12.76	8.24	6.85	2.78	30.63	18.27	48.64	115.34	16.42	198.66
Z_2 - FS	58.44	33.32	53.66	23	168.41	12.59	8.47	6.86	3.23	31.14	19.14	51.9	123.07	18.1	212.2
SE(m)±	0.43	0.34	0.58	0.28	1.02	0.119	0.083	0.071	0.073	0.195	0.09	0.47	1.24	0.23	1.79
CD at 5%	1.25	0.98	1.67	0.81	2.95	0.342	0.239	0.204	0.21	0.562	0.26	1.35	3.58	0.66	5.15
C) Interaction (A x B)															
SE(m)±	1.23	0.96	1.64	0.8	2.89	0.336	0.235	0.201	0.206	0.552	0.25	1.32	3.51	0.65	5.06
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

and at dough stage of $ZnSO_4$ @ 0.5 % recorded significantly highest phosphorus content (0.09 %) and phosphorus uptake (6.86 kg ha^{-1}) by stem. The phosphorus content (0.12 %) and uptake (3.23 kg ha^{-1}) registered significantly higher with soil application and foliar sprays in roots. The results are in agreement with the findings reported by Patil *et al.* (2008). The soil application of Zn @ 5 kg ha^{-1} with two foliar sprays before flowering and at dough stage of $ZnSO_4$ @ 0.5 % recorded significantly highest total phosphorus uptake (31.14 kg ha^{-1}).

The soil application of Zn @ 5 kg ha^{-1} with two foliar sprays before flowering and at dough stage of $ZnSO_4$ @ 0.5 % recorded significantly highest potassium content in grain (0.59 %), leaves (1.34%), stem (1.56%) and root (0.67%). The significantly highest potassium uptake by grain (19.14 kg ha^{-1}), leaves (51.09 kg ha^{-1}), stem (123.07 kg ha^{-1}) and root (18.10 kg ha^{-1}) and total uptake of potassium were recorded highest with soil application of Zn @ 5 kg ha^{-1} along with two foliar sprays before flowering and at dough stage of $ZnSO_4$ @ 0.5 %. This might be due to synergetic interaction between Zn and K, many zinc dependent enzymes that are involved in carbohydrate metabolism, maintain water balance within the soil-plant-atmosphere continuum.

Increase in K content in stem might be due to increase with application of zinc. Ali *et al.* (2011) reported that Zn sufficiency was associated with marked increase in K efflux from root and shoot into growth medium. The soil application of Zn @ 5 kg ha^{-1} and two foliar application of $ZnSO_4$ @ 0.5 % increased 17.89 per cent total potassium uptake over control while soil application of Zn @ 5 kg ha^{-1} increased total potassium uptake by 10.37 per cent (Table 3).

It can be concluded that, sorghum genotype CSH-35 recorded higher grain yield with soil application of Zn @ 5 kg ha^{-1} with two foliar sprays before flowering and at dough stage of $ZnSO_4$ @ 0.5 %. The nutrient content (NPK) recorded higher in CSH-35 while AKSV-161 registered higher dry matter of leaves, stem and roots besides higher nutrient uptake. The soil application of zinc along with foliar application showed higher grain yield, nutrient content and uptake.

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