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CYTOPLASMIC NUCLEAR MALE STERILITY IN SORGHUM (*Sorghum bicolor* (L.) MOENCH) – CURRENT STATUS AND FUTURE PROSPECTS

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ABSTRACT

Discovery of cytoplasmic nuclear male-sterility has revolutionized sorghum production. As a result of extensive breeding efforts, hybrids are available for sorghum cultivated for diverse uses such as grain sorghum, sweet sorghum and forage sorghum. Almost all the hybrids are based on A1 CMS system. In order to have an alternate source in case of vulnerability of cytoplasm to any disease in future, there is a need to diversify the cytoplasm base. In addition to the A1, several other cytoplasmic sources, like A2, A3, A4,A5, A6, 9E and KS cytoplasms differing from each other were identified. The alternate cytoplasms have been characterized and studied for grain yield and agronomic traits, resistance to pests and diseases and the outcome of the research are presented.

Key words: sorghum, cytoplasmic nuclear male-sterility, hybrid, grain mold, shoot fly

Cytoplasmic-nuclear male-sterility is a maternally inherited trait characterized by the inability of plants to produce viable and/or functional pollen grains. It was discovered in 1921 in two strains of flax (*Linum usitatissimum* L.), which produced nearly 25% male-sterile F2 progeny when crossed in one direction but not the other (Bateson and Gairdner, 1921). Cytoplasmic male-sterility has been observed in more than 150 plant species (Kaul, 1988). Cytoplasmic-nuclear male-sterility results from an interaction of a sterile (S) cytoplasm and homozygous recessive alleles (rf/rf) at one or more nuclear fertility restorer genes. When a dominant nuclear fertility restorer allele (Rf) is present, fertility is restored irrespective of whether a sterile (S) or normal/fertile (N/F) cytoplasm is present. Thus, plant species exhibiting CMS possess both rf (male-sterility maintainer) nuclear genes as well as N/F- or S-cytoplasm types. Dominant nuclear fertility restorer genes (Rf) restore the self-fertilization ability of hybrid plants having the male-sterility-inducing S-cytoplasm and are indispensable in CMS-based hybrid cultivars of crops in which fruit or seeds are harvested, such as cotton, pearl millet, sorghum, and rice.

The discovery of cytoplasmic nuclear male-sterility (CMS) in sorghum by Stephens and Holland (1954) and its subsequent exploitation for hybrid production has revolutionized sorghum production worldwide. Stephens and Holland (1954) reported the first usable sources of cytoplasmic male-sterility in crosses involving *Day Milo* with *Kafir* and *Milo* with Black hull *kafir* resulting in male sterility from the introduction of *kafir* genes into *Milo* cytoplasm. Cytoplasmic male-sterility in this system is due to the interaction between genes in *Milo* cytoplasm and *Kafir* nucleus. The degree of male sterility increases with the proportion of *Kafir* genes in *Milo* cytoplasm. For inducing male sterility in *kafir* cytoplasm, genes at both the loci are required whereas only one gene is required for inducing male sterility in *Milo* cytoplasm.

In sorghum, the first commercial hybrids were produced in 1956 on some strains of combine *kafir* (Quinby *et al.,* 1958). Later, the cultivars Martin, Wheatland, two Redbines and Redlan had been male sterilized and hybrids with those parents went into production. The availability of male sterile line combined *kafir* 60 from USA provided the opportunity to exploit hybrid vigour and thus usher in the era of high yielding hybrids in India. The first sorghum hybrid CSH 1 was commercially released in 1964 (Rao and House, 1966). Since the chalky white grains of *kafir* place a limitation on grain quality, immediate efforts were directed towards developing new male steriles with corneous endosperm through substitution backcrosses in *milo* cytoplasm which is designated as A1 cytoplasm.

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Hybrid sorghum development in Indian national program

In Indian sorghum improvement program, most of the hybrids were developed for *kharif* grain sorghum production.The early efforts (from 1962-69) resulted in the development of the hybrids, CSH 1, CSH 2 and CSH 3. These were followed by the release of more popular hybrids, like CSH5 and CSH 6 in the mid-1970s and CSH 9 in the early 1980s, augmenting the spread of sorghum HYVs.During 1980s, the hybrids CSH 10 and CSH 11 and during 1990s, CSH 13, CSH 14, CSH 16, CSH 17 and CSH 18 were released and among them, CSH 16 developed from new MS line 27A and the R-line C 43 became popular and is still preferred by farmers. This hybrid showed improvement in grain mold tolerance as the grain mold resistant genes from Ethiopian germplasm line IS 23549 were introduced to its male parent. From the year 2000 onwards, the hybrids CSH 23, CSH 25, CSH 27 and CSH 30 were released for *kharif* season adaptation. Unlike in the case of *kharif* sorghum, where 90% of the area is dominated with hybrids, *rabi* sorghum varieties have better preference over hybrids for reasons of adaptability and grain quality.The released post-rainy sorghum varieties, CSV 8R, CSV 14R, CSV 18 and Swathi, were better received than the post-rainy hybrids such as CSH 7R, CSH 8R and CSH 12R released in 1980s. The hybrids CSH 13R and CSH 15R released during 1990s were comparatively better received but did not possess the grain quality of M 35-1, the widely cultivated *rabi* sorghum landrace. Later on, a hybrid CSH 19R was released in 2000. But it could not make any impact in farmers fields. The sweet sorghum improvement program has received considerable attention since two decades. As a result of it, the varieties SSV 84, CSV 19SS and CSV 24SS and a hybrid CSH 22SS were released and being grown by the sweet sorghum farmers. For the improvement of forage sorghum, breeding was initiated in 1970s and several single cut varieties were released. In 1977, a multicut forage sorghum variety, SSG 59-3, developed from a cross between forage sorghum and sudan grass, was released and it became popular. As seed production became difficult for this variety, it could not be largely cultivated by farmers. However, forage sorghum varieties dominated in eighties. In the 1990s, the hybrids received attention and several private sector companies also came forward and released several hybrids. Some of the hybrids include Punjab Sudex Chari, Pro-Agro Chari, MSFH-3, Hara Sona and Safed Moti. The nationally released multi-cut forage sorghum hybrids, CSH 20MF and CSH 24MF became popular and currently under cultivation. All the hybrids released so far in the Indian national program were based on A1 CMS system.

Alternate CMS systems in sorghum

Present day grain sorghum hybrids depend on a single cytoplasmic genic male sterility system that might pose potential hazards. Although cytoplasmic susceptibility to disease appears to be rare (Hooker, 1970), the USA experience with the maize leaf blight epidemic of 1970 (Tatum, 1971) is a warning of the danger of reliance on a single source of cytoplasmic male sterility in sorghum. The role of cytoplasms in causing susceptibility or resistance is well established in corn and wheat (Hooker, 1970). Recognizing the problem, several attempts have been made to find out new sources of cytoplasmic genic sterility in sorghum. The research work on development and basic studies of diverse cytoplasms were reported from USA and India. The work on this aspect is reviewed by Rao (1972) and Schertz and Pring (1982). Quinby (1982) analysed the role of gene cytoplasm interactions in sex expression.

Studies on alternate CMS systems in US

A single cytoplasm type, tracing to the *milo* source used by Stephens and Holland (1954), still is used to induce male sterility in seed parents. Several alternative cytoplasms have been reported from five grass type sorghums (Ross and Hackerott, 1972). The Kansas and Nebraska Agricultural experiment stations and USDA in 1971 released seven grain sorghum lines KS 34 to KS 40 with cytoplasm from the non-cultivated grassy sorghums. KS 34 to KS 39 are cytoplasmic sterile types with the CK 60 genome. Sterility is maintained with CK 60B. Each of the KS male steriles and CK 60 (*milo* cytoplasm) was crossed by a series of testers. The test cross progenies of male steriles KS 35, KS 36 and KS 37 by specific male parents were male fertile than the progenies of the CK 60, KS 34, KS 38 and KS 39 male steriles by the same testers. Restriction analysis of mt DNA from the six KS male sterile lines using several endonucleases revealed two sub-groups. The correspondence of fertility and mt DNA data supported the idea that the cytoplasms of KS 35, 36 and 37 differ from the cytoplasm of *milo* and the

other three KS lines (Conde *et al.,* 1982). Male sterile lines due to non-dehiscent anthers have been developed from progenies of crosses with an African variety, 9E. The breeding behaviour of these lines is similar to that of A lines from cytosteriles. The feteritas act as restorers in crosses with the non-dehiscent steriles. The F1 progenies from crosses with most other groups of sorghums are sterile (non-dehiscent). Cross 9E x Leoti was sterile and Leoti x 9E was fertile and thus showed reciprocal differences. Sterility in this line is maintained by *kafir*s and also by *milo*s (Webster and Singh, 1964). Several lines, including DD Sooner *Milo*, have been sterilized in 9E cytoplasm and sterility of those A lines was evaluated in tests at five locations (Webster, 1980). The 9E sterile line was test crossed and compared with other steriles of Texas programme. The studies of mitochondrial and chloroplast DNA of 9E differs from *milo* (Pring *et al.*,1982) as did polypeptide studies of Dixon and Leaver (1982). A brief summary of different cytoplasmic sources is presented in Table 1.

Table 1. Summary of different cytoplasmic genetic male sterility systems identified in *Sorghum bicolor* L. Moench

Group	Source	Restorer source	Genetics	Referenece
A1	*Milo*	Numerous including TX430	Simple, dominanat, sporophytic	Worstell *et al*(1984) & Klein *et al* (2001b)
A2	IS12662C	Numerous including IS2801C, TX430	Simple, dominanat, sporophytic	Worstell *et al* (1984)
A2'	IS3063C IS 1056C	IS 2801 C	Simple, dominanat, sporophytic	Worstell *et al* (1984)
A3	IS1112C IS12565C	IS1112C	Simple, two genes, gametophytic	Worstell *et al* (1984)& Tang and Pring (2003)
A4	IS7920C	IS2801C	Unknown	Worstell *et al* (1984)

(Rooney, 2004)

Studies on alternate CMS systems in India

Considerable progress has been made and several alternative cytoplasms are reported in India. Mittal *et al.* (1958) reported the occurrence of a male sterile in line IC 2360. Rao (1962) reported male sterile plants in varieties WEI Bilichigan, *Erra Jonna*, Indore Local, GJ 103, BD 8, Burma black, Norghum and C 10-2. Hussaini and Rao (1964) reported two additional male sterile plants in PJ 22K and a white seeded variety from Warangal. NGP Rao and his colleagues identified some of the male sterility inducing cytoplasms (Rao, 1962) and reported in subsequent series (Rao, 1972). Appathurai (1964) observed that male sterility in G1 and G2 were not identical. The G2 cytoplasm is stronger in its effect of producing male sterility as the gene from G1 is not able to restore fertility in G2 while it restores fertility on MS 1601 (CK 60A). A sterile from G1 was isolated and it was designated as G-2-S.

Rao (1972) in the "Sorghum in seventies" symposium reviewed the work on male sterility in India and gave details regarding the new sterility inducing cytoplasms. The new cytoplasmic sources reported in 1962 (Rao, 1962) were used to convert M 35-1 (an Indian winter sorghum) and IS 3691 a yellow hegari, into sterile lines. Both M 35-1 and IS 3691 are restorers in the *milo-kafir* system. Additional sources of cytoplasmic sterility have been reported by Hussaini and Rao (1964) in durra (G2, VZM1 and VZM2). At Raichur indigenous sterile line M 31-A is said to owe its origin to induced mutation. Nagur (1971) gave *S. dochna* as the source of cytoplasm in male sterile M 35-1 and *S. cernum* as the source of cytoplasm of male sterile M 31-2. The cytoplasm in the male sterile of M 35-1 is A_2 and the cytoplasm in M 31-2 is probably A_2 cytoplasm (Quinby, 1980). Alternative sources reported by the Indian workers are basically from traditional local varieties. Main male sterile types included

Maldandi (M 35-1A, M 31-2A), Guntur (G1A) and Vizianagaram (VZM2A) lines. In the last few decades Indian agriculturists and plant breeders under the All India Coordinated Sorghum Improvement Project have developed several male sterile lines based on three Indian male sterile cytoplasms designated as Maldandi, Guntur and Vizianagaram. These cytoplasms are of Indian origin (race *durra*) and have been identified separately in the regions of Maldandi, Guntur and Vizianagaram. They have been tentatively grouped as Indian A_4 types and the Indian A_4 group is different from the American A_4 group (Sane *et al.*,1996).

Characterization of diverse cytoplasms in sorghum

Differences in fertility characteristics of progenies from reciprocal crosses remain the primary indication of male sterile cytoplasms today. Nagur and his colleagues (Nagur 1971; Nagur and Madhava Menon, 1974) studied fertility character of six male steriles; CK 60A, G1A, VZM 1A, VZM 2A, M 31-2A and M 35-1A, their maintainer lines and 63 unrelated fertile types. Forty two of the males could restore fertility in CK 60A but not on the rest. Five lines which were restorers on *milo* were partial restorers on M 31-2 but not on the other four lines. Therefore, it was concluded that M 31-2 has different cytoplasm from the rest. Two more male parents were found to be restorers on VZM2A but not on G1 and M 35-1. Fertility on the latter two lines was restored by two more lines (AS 557 and AS 689) that could not do so on VZM1 and VZM2. This behavior was thought to be sufficient to distinguish them from VZM1A and VZM2A. Four different cytoplasms were thus distinguished, S1 (*milo*), S2 (G1, M 35-1); S3 (VZM1 and VZM2) and S4 (M 31-2A).

Cytoplasmic male steriles reported from India have different restoration systems compared to the *milo-kafir* system. F1 studies on pollen sterility, pollen shedding and seed set enabled the classification of the cytoplasmic sources as shown in Table 2.

Table 2. Cytoplasmic male sterility systems reported in India

Type of cytoplasm	Line
A1	CK 60A, Nagpur A
A2	M35-1A, M31-2A
A3	VZM2A, G1A

(Tripati *et al* , 1980 and Rao *et al*, 1984)

A diallel set of crosses including reciprocals with nine parents enabled cytoplasmic characterization of the B and R lines (Rao *et al.,* 1984). The cytoplasm of G1B and Nandyal tended to exhibit greater levels of pollen sterility while those of CK 60B and Karad-local tended to promote greater levels of male fertility. The B line cytoplasms were again grouped into three

(i) B1 -CK 60B and Karad local,

(ii) B2 - M 35-1B and VZM2B

(iii) B3 - G1B and Nandyal.

The diversity of the Indian cytoplasmic systems is further confirmed by soluble protein patterns, isozyme differences, aminoacid composition, pollen grain shape, size, exine sculpture, internal sculpture (Tripathi *et al.,* 1981a, 1981b, 1982a, 1982b and 1983). Iso-sterile set involving postrainy lines R 16 and FR 493 and diverse cytoplasms (M 35-1, VZM and G1) is developed (Tripathi, 1979).

Quinby (1980) has proposed an ingenious hypothesis to account for and explain the nature of diversity of cytoplasm in sorghum and reported that there should be two female inducing (A_2 and A_3), two male inducing (B_1 and B_2) and a neutral (A_1) cytoplasm. The cytoplasm of IS 1112C or converted Nilwa of Indian origin has been designated as A_3 (Quinby, 1980). Progeny of crosses between 13 nearly isogenic male sterile female lines with different cytoplasms and 8 male lines were evaluated for grain set and other traits at 8 localities. Cytoplasms from diverse sources were classified into four groups viz., A_1, A_2, A_3 and A_4. *Milo* (A_1) and A_2 cytoplasm types differed only in degree of fertility restoration. Hybrids with A_3 cytoplasm (IS 1112C and IS 12565C) gave fertility reaction opposite to those with A_1. A_4 cytoplasm (IS 7920C) was similar to A_3 on five of eight testers, but unlike all cytoplasms on the other three testers. Sterile plants with A_3 had 1-3 per cent filled pollen grains, while those with A_4 had 71 per cent. A_4 steriles were characterized by indehiscent anthers. Examination of anthers and pollen distinguished three types of male steriles consistent with the distinctions by seed set characteristics. In A_1 and A_2cytoplasms, anthers were small, collapsed and pointed. No stainable pollen grains were observed. Rarely present empty exines were usually clumped. In A_3 and A_4 cytoplasmic types, the anthers and pollen grains were intermediate between normal and A_1 and A_2. Among these cytoplasms, there are four distinct

groups viz., A_1, A_2, A_3 and A_4 which differ in their fertility characteristics. An iso-sterile set with these four cytoplasms was developed which is maintained by BTx398 (Worstell *et al.,* 1984). Reddy and Stenhouse (1994) reported the identification of minimum differential testers for A_1 to A_4cytoplasms as:

TAM 428B (A_2) gives fertile F_1s only on A_1 cytoplasm,

IS 84B (A_4-Maldandi) gives fertile F_1s on A_1 and A_2cytoplasms,

IS 5767R (A_4-Maldandi) gives fertile F_1s on all cytoplasms, except A_3, and

CK 60B (A_1) gives male-sterile F_1s on all cytoplasms.

Based on pollen development and anther morphology, these A_1 to A_4 (Guntur, VZM, Maldandi) and 9E cytoplasms were further subdivided into two distinct groups: (i) those with small anthers but without fertile pollen which degenerates during microsporogenesis (A_1, A_2, A_5, and A_6) and (ii) those with large non-dehiscent anthers that may contain some viable pollen (A_3, A_4, and 9E) (Schertz *et al.,* 1989). A_1 to A_4 CMS cytoplasms are being maintained at Patancheru (Andhra Pradesh, India) by ICRISAT.

The lack of differential restoration patterns, however, does not provide conclusive evidence that the CMS sources involved are necessarily similar as it is possible that the pollinator parents used in developing the testcrosses were not adequate in number and diverse enough to pick up the CMS differences. It is also important in such field studies that testcrosses to be evaluated are made on isonuclear A-lines to ensure that genotypic differences of the female parents are not confounded with their cytoplasmic differences in determining fertility restoration of testcrosses.

This diversity is further confirmed by various biochemical studies as presented in Table 3.

Table 3. Molecular differentiation of male-sterile and fertile cytoplasms in sorghum

Technique/gene/marker/clone	Characteristics	References
N1 and N2 plasmid-like DNAs	Differentiated A3 cytoplasm of IS 12563C and IS 1112C at plasmid sizes 1.7 and 2.3 kb.	Chase and Pring(1986)
Restriction endonuclease enzymes	Differentiated sterile and fertile, and A1, A2, A3 and A4 CMS cytoplasms.	Bailey *et al* (1986)
coxI clone	Differentiated 9E (IS 17218) and A4 (IS 7920C) cytoplasms at HindIII fragment size 1.9 kb.	Bailey *et al* (1986)
atp6 probe	Differentiated 9E and A4 cytoplasms.	Pring *et al* (1998)
rrn18 and *rrn 26* probes	Differentiated between KS 37 and KS 39	Pring *et al* (1998)
orf107 gene	Mitochondrial gene *orf*107 is associated with male-sterility	Pring *et al* (1998)
atp6 probe	Differentiated Texas fertile and A3 cytoplasms at *orf* 25.	Nagur (1971) and Muller *et al* (1992)
Restriction enzyme	The A1 and A2 cytoplasms have identical HindIII patterns, while Bam HI-digested ctDNA produced the same patterns in A2, A3 and A4, and *Eco* RI and *Pst* I produced identical patterns in all four cytoplasms.	Thin *et al* (1993)

Technique/gene/marker/clone	Characteristics	References
RFLPs	Classified Indian origin CMS (Maldandi, Guntur, Vizianagaram) as Indian A4 types, and distinguished from the American A4- and A1-types.	Sane *et al* (1996)
RFLPs	Mitochondria of fertile 2219A have more respiring efficiency and mitochondrial electron transport (ET) rates from NADH to oxygen than CMS line, thus indicating responsible for male sterility.	Nath *et al* (1992) and Arora *et al* (1993)
RFLPs	Restriction fragment locations of various mitochondrial genes and their transcripts suggest polymorphism for genes related to the ATP synthase complex between CMS and maintainer cytoplasms.	Sane *et al* (1994)

(Source: Dhillon *et al*, 2008)

Identification of restorers for diverse cytoplasms in sorghum

According to Schertz and Pring (1982) and Schertz *et al.* (1989), mainly three CMS groups (Indian, Kansas, and Texas) are predominant in sorghum. In addition to the *Milo*-cytoplasm (A_1), cytoplasmic male-sterile lines are also available in A_2, A_3, A_4, $A_{4(M)}$, $A_{4(VZM)}$, $A_{4(G)}$, A_5, A_6, 9E and KS cytoplasms (Nagur, 1971; Schertz *et al.*, 1997; Rao *et al.*, 1984; Worstell *et al.*, 1984; Xu *et al.*, 1995). In contrast, the difficulty with *milo* cytoplasm is that it is generally not effective in sterilizing some of the desired lines. Most breeding lines act as restorer for *milo* cytoplasm. This situation restricts the utilization of better lines as females with *milo* cytoplasm. The non-utilization of alternative sources of cytoplasms has been mainly due to lack of information on their restoration, maintenance and characterization. The heterotic potential of these alternate cytoplasms has not been exploited so far because of lack of appropriate restorer lines (Nagur, 1971; Tripathi, 1979). For utilization of diverse cytoplasmic systems, it is essential to identify agronomically desirable restorers.

Fertility restorers on A_2 cytoplasm are reported by Schertz and Ritchey (1977) and Quinby (1982). Cultures IS 2801C, IS 12680C, IS 12567C and IS 12662C have restored fertility on A_2 cytoplasm (Worstell *et al.,* 1984). A total of 14 lines are now known to restore complete fertility on A_2 cytoplasm including lines like 53, 122, R 473 etc (Murty and Vidyabhushanam, 1985; Gangadhar, 1986). Partial restoration was reported on A_3 cytoplasm (Quinby, 1982; Worstell *et al.,* 1984). All the Indian lines tested have given maintainer reaction with A_3 (Murty and Vidyabhushanam, 1985). Worstell *et al.* (1984) also reported partial fertility restoration in A_4 crosses with lines like IS 2801C and IS 12680C. Rao *et al.* (1984) established cytoplasmic effects of A, B and R lines. In Indian A lines, the degree of sterility increases from A_1, A_2, A_3 and consequently fertility restoration also becomes increasingly difficult in the same order. Cytoplasmic factors in A and B lines appear to be in opposite directions. Tripathi *et al.* (1985) observed fertility restoration of Maldandi cytoplasm with Indian local varieties like GM1-5 and Karad local. Majority of restorers reported for diverse cytoplasms are agronomically undesirable (Borikar*et al.,* 1987). The diverse Indian and exotic cytoplasmic systems have potential for providing wide range of variability among parents and hybrids, but their utility for such purposes remains to be tested.

To determine the distribution and geographic specificity of sterility maintainers and fertility restorers, 128 diverse sorghum germplasm accessions from world sources have been evaluated by crossing them with three male-sterile lines viz., 296A, M 31-2, and SB 2418A representing *Milo*-cytoplasm (Parameshwar Goud *et al.*, 1998). Among these, 61 lines were

identified to be male-fertile, of which 49 restored on *Milo*, 17 on Maldandi and 4 on VZM cytoplasm. These studies indicated that indigenous lines should be collected and screened to identify restorers for Indian cytoplasm (Maldandi and VZM), and the identified maintainer lines may be used for generating new male-sterile lines on different cytoplasm background, while restorers can be used to produce commercial hybrids. (Reddy and Rao, 1992).

Genetics of fertility restoration in sorghum

The genetics of fertility restoration with reference to *milo-kafir* system is critically reviewed. Maunder and Pickett (1959) reported the role of single recessive nuclear gene in *milo-kafir* system. Subsequent studies reported the operation of two (Schertz and Stephens, 1966; Appadurai and Ponnaiya, 1967) or three (Joglekar and Deshmukh, 1961; Cragmiles, 1961; Erichsen and Ross, 1963; Patil and Rane, 1968; Tripathi *et al.,* 1985) gene system governing cytoplasmic genetic male sterility. Miller and Pickett (1964) reported the operation of Pf1 and Pf2 genes governing partial fertility. Atleast two major genes were found to be necessary for fertility restoration on A_2 cytoplasm, unlike A_1 where a single dominant gene was found to be responsible for fertility segregation (Gangadhar, 1986). Tripathi *et al.* (1985) studied the genetics of fertility restoration with Maldandi cytoplasm which cannot be explained unless non-allelic gene is present in addition to the three genes. But even then it is only three gene interaction which restores fertility in Maldandi cytoplasm. Research at ICRISAT showed that the frequency of recovery of fertile plants were least on A_3 than A_2 and A_4 and A_1 indicating that more number of genes are involved in controlling fertility restoration on A_3 than the other systems (Reddy and Prasad Rao, 1992). The four gene system is still inadequate to bring about fertility restoration on VZM or G_1steriles. A genotype homozygous at all the four dominant MSC loci or an additional MSC5 locus may only restore fertility on G_1 and VZM steriles. Till such a genotype is available, the full genetics of restoration has to wait (Tripathi *et al.,* 1985). In a study involving iso-nuclear, allo-cytoplasmic hybrids, it was found that the fertility restoration of A_1CMS system was governed by one basic gene and twoduplicate complimentary genes (45F:19S in F2) all actingin dominant fashion while the fertility restoration of A2 and A3 CMS systems was governed by three genes whereall of the three complimentary genes in dominant condition restore fertility (27F:37S in F2). The fertility restoration in A4(M) CMS system was governed by three genes where any two of the three dominant duplicate-complimentary genes restored fertility (54F:10S in F2) in post-rainy season while two complementary genes in dominant state restored fertility (9F:7S in F2) in rainy season in the absence of expression of the third gene (Sanjana Reddy *et al.,* 2010).In literature, a total of six (ms1 to ms6) genes causing genetic male sterility have been reported. It is likely that these very genes which interact with appropriate cytoplasmic sources. This point needs to be confirmed.

Influence of cytoplasm on various traits in sorghum

Influence of CMS on agronomic and grain yield related traits

Concurrent with the development of male sterile lines in different cytoplasmic backgrounds, it was necessary to determine the effect of cytoplasm on agronomic performance. However, studies evaluating the agronomic potential of different CMS systems are inconsistent in their results. Previous studies on effect of CMS sources on agronomic traits are presented in table 4.

Table 4. Influence of male-sterile/male fertile cytoplasms on Agronomic traits

Crop/Traits	Cytoplasm	Effect	References
Grain yield, seeds/panicle,100-seed weight, panicles per plant, leaf length and area, leaves per plant and days to flowering.	MS1 versus MF2	Yes	Lenz and Atkins (1981)
Grain yield components	MS versus MS	No	Lenz and Atkins (1981)
Grain yield, plant height, panicle length and excretion, flowering and grain moisture	MS versus MS	No	Lenz and Atkins (1981), Ross and Kofoid(1979), Williams *et al*(1992) and Williams *et al* (1994)

Crop/traits	Cytoplasm	Effect	References
Plant height and days to 50% flowering	MS versus MS and MS versusMF	Yes	Dhillon(2004) and Dhillon et.al (2005)
Grain yield and other agronomic traits	MS versus MS	No	William & Rodriguez(1994) and Secrist & Atkins (1989)
Grain size, yield and yield components	MS versus MS	Yes	Gangakishan & Borikar (1989), Wang *et al* (1990)
GCA and SCA of morphological traits	MS versus MS	Yes	Wang *et al* (1990)
Days to flowering, inflorescence length and plant height	MS versus MS	No	Pecina *et al* (1994)
Agronomic and morphological traits, pollen fertility and seed set	MS versus MS	Yes	Kishan *et al* (1991), Senthil & Palanisamy (1995), Chen *et al* (1995)
Heterosis for yield	MS versus MF	Yes	Nurbekov (1990)
Days to flowering, plant height, grain yield and forage quality	MS versus MF	No	Pederson (1997)
Seed setting	MS versus MS	Yes	Pederson (1997)

(Source: Dhillon *et al*, 2008)

Evaluation of two sets of 36 hybrids obtained by crossing two different sets of six A_1 and A_2 isonuclear CMS lines with common three dual restorers at Patancheru during rainy seasons of 2001 and 2002 indicated A_2 CMS system is comparable to the widely used A_1 system for plant height with a slight advantage of A_2 in favor of A_1 in terms of frequency of hybrids with significant SCA effects and mid-parent heterosis for days to 50% flowering and grain yield (Reddy *et al.,* 2007).

CMS lines containing A1, A2, A5, A6 cytoplasms display the 165 bp deletion in the middle of rpoC2, the plastid gene which encodes the RNA polymerase beta" subunit. These lines have small anthers in which pollen development is arrested at an early stage and in which usually only empty exines are found. CMS lines containing A3, A4, and 9E cytoplasms do not possess the deletion. These lines have large anthers in which pollen degenerates at a later stage (Chen *et al.* 1995). In grain sorghum hybrids the effect of cytoplasm on performance of grain sorghum hybrids has varied, depending on study. Maves and Atkins [1988] reported a reduction in grain yield in A2 hybrids compared to A1 hybrids while Kishan and Borikar [1989] reported that A2 was superior to A1 for grain size and yield. Secrist and Atkins [1989] found no significant differences in grain yield between A1 and A2 hybrid, but they reported a 6% reduction in grain yield in A3 hybrids compared to A1 hybrids. Moran and Rooney [2003], evaluating iso-cytoplasmic hybrids also reported reduced grain yield in A3 hybrids compared to both A1 and A2 hybrids. In forage sorghum, Pedersen and Toy [1997] tested the effect of A1 and A3 cytoplasm in forage hybrids of sorghum × sudan- grass, and they found no differences associated to cytoplasm alone for maturity, height, dry yield, total yield, crude protein and in vitro dry matter disappearance.

Across environments, significant differences existed among hybrids for both agronomic and compositional traits, but cytoplasm *per se* had no effect on any plant height, biomass yield and biomass components (Hoffmann and Rooney, 2013).

Influence of CMS on traits contributing to insect pest resistance

The development and release of new sorghum hybrids and varieties marked a genetic breakthrough in terms of yield potential, but their high susceptibility to shoot fly has been a major constraint in popularizing these hybrids. Economic injury levels for shoot fly damage on CSH 1 (3.8 to 9.6%), CSH 5 (3.4 to 8.5%)

and Swarna (5.9 to 15.0%) have been reported to be quite low (Samarjit Rai *et al.*, 1978). In view of seriousness of the shoot fly problem, it has been realized that there is a need to breed shoot fly resistant hybrids based on cytoplasmic male sterility. However, an understanding of the effects of CMS on the expression of resistance to shoot fly is a prerequisite to formulate a plan for hybrid production. Since, future breeding efforts will largely focus on high yield and shoot fly resistance, it is also important to understand the mechanisms and inheritance of resistance in crosses involving shoot fly-resistant and shoot fly-susceptible males (restorers) and females (CMS). Use of A1, A2, A3,A4(M), A4(G), A4(VZM) cytoplasms should not increase the risk of shoot fly in commercial grain production. Overall, the A4(M) cytoplasm seemed to contribute to shootfly resistance in hybrid combinations (Sanjana Reddy *et al*., 2015).

Ross and Kofoid (1979) report that the KSA 34 to KSA 39 CMS lines are as susceptible as Combine *Kafir* based CMS lines for green bug, *Schizaphis graminum*. Cytoplasmic male-sterility has been reported to influence expression of resistance to sorghum midge (Sharma, 2001). Sharma *et al.* (1994) reported low midge damage and adult emergence on midge resistant B-lines as compared to their corresponding A-lines, which may be because of the genic-cytoplasmic male sterility. There were no differences in midge damage and adult emergence between midge-resistant and susceptible A-line. Therefore, it may be inferred that there are some additional factors linked with the genic-cytoplasmic male sterile A-lines, which affect the oviposition and development of sorghum midge. Resistance to sorghum midge is governed by additive genes (Sharma *et al.*,1994) and nature of gene action is dominant (Faris *et al.,* 1976; Agrawal *et al*., 1988)., suggesting that resistance is needed in both the parents to produce midge resistant hybrids. Resistant CMS x susceptible restorer based hybrids have been found to be less susceptible than susceptible CMS x susceptible restorer hybrids (Johnson, 1977, Sharma *et al.*, 1994). At ICRISAT, the maintainer lines (B) flower early by one or two days and has more open panicles than those of their A-lines. Further, A_1 cytoplasm was more susceptible to shoot fly than the maintainer line cytoplasm, while the reverse was true for stem borer resistance (Reddy *et al.,* 2003). This finding has significance in developing shoot fly and stem borer resistant hybrids.

Influence of CMS on traits contributing to disease resistance

Grain mold, a highly destructive disease of sorghum (*Sorghum bicolor* (L.) Moench), is widely distributed in the semi-arid tropics of Africa, Americas and Asia including India (Stenhouse *et al.,* 1997). Grain mold is broadly defined as pre-harvest grain deterioration caused by several fungal genera interacting parasitically and/or saprophytically with developing grain (Thakur *et al.,* 2006). In India, *Fusarium verticillioides*, *Curvularia lunata* and *Alternaria alternata* are more pathogenic than others (Thakur *et al.,* 2003). The disease is particularly important on improved, short- and medium duration sorghum cultivars that mature during rainy season in humid tropical and sub-tropical climates. Grain mold results in reduction of seed mass, seed germination, and storage and food/ feed processing quality and hence market value. Production losses due to grain mold range from 30% to 100% depending on the cultivar, time to flowering and prevailing weather conditions during flowering to harvesting (Singh and Bandyopadhyay, 2000). As compared to other cytoplasms, the A1 cytoplasm based hybrids were more tolerant for grain mold (Sanjana Reddy et al. 2011). A cross of tan restorers with tan cytoplasmic male-sterile lines expresses tan color in hybrids with high levels of resistance to rust and head blight as compared to other cross combinations. Hybrids based on red CMS line x tan restorer also give comparatively high expression of tan color and resistance to both the diseases over red x red and tan x red hybrids, which are at par with tan x tan crosses (Torres-Montalvo *et al*., 1992). The restorer characteristics are dominant over cytoplasmic male-sterile parent. If both CMS and restorer lines have resistance, then the hybrids show high level of resistance. The resistance traits are carried over from male/restorer parent to their progenies.

CONCLUSION

A number of CMS sources of different genetic background with suitable restorers and maintainers have been identified in sorghum and their influence on resistance to pests and diseases is also generated. However there is every chance of outbreak of pests and diseases under limited sources of CMS. Thus research on identification of new sources of CMS and conversion of various sources of resistance to pests and diseases into these CMS sources to develop sustainable hybrids should be in continuum.

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Research Article
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HETEROSIS FOR YIELD AND YIELD ATTRIBUTES USING LINE X TESTER DESIGN IN RICE (*Oryza sativa* L.)

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ABSTRACT

The present investigation was carried out to study the magnitude of heterosis in yield and its component traits of 20 rice hybrids developed by crossing five lines with 4 testers in a line x tester mating design at Agricultural Research Station, Nellore, AP. Mid parent and heterobeltiosis ranged from 1.82 to 89.14% over mid parent and -6.7 to 80.67% over better parent respectively. The hybrids *viz*., BPT 5204 x NLR 34449 followed by BPT 5204 x IR 36, BPT 5204 x IR 64, and WGL 48684 x IR 36 recorded highly significant positive heterosis for the trait grain yield over mid parent and better parent and these hybrids could be identified as best for exploiting the heterosis.

INTRODUCTION

Rice is the staple food for more than 40% of the world's population. Millions of the people depend on it, as a source of food and income. Thus, it requires a continuous improvement in productivity, besides profitability in rice farming system on sustainable basis. The exploitation of hybrid vigour appears to be the appropriate alternative for making further breakthrough in rice yields. The success of any yield improvement programme depends on the magnitude of heterosis that helps in the identification of potential cross combinations to be used in the conventional breeding programme so as to create wide array of variability in the segregating generations. The knowledge on the genetic aspects is very important for maximum exploitation of heterotic effects in rice hybrids and /or for building up of gene pools to be employed in breeding programme. The present study was therefore performed to estimate the magnitude and direction of heterosis for important yield attributing traits in rice.

MATERIAL AND METHODS

The experimental materials used for the present investigation consisted of F_1 hybrids of 20 crosses developed by crossing 5 lines/genotypes of rice *viz*., BPT 5204, MTU 1010, WGL 48684, RNR 2465 and JGL 11118 with four testers *viz*., NLR 34449, NLR 145, IR 36 and IR 64. All the lines used as female parents were crossed to each of the testers by hand pollination during *kharif,* 2014. The F_1's (20 hybrids along with parental lines (lines (5) + testers (4)) were evaluated in RBD with three replications at Agricultural Research Station, Nellore. In each replication entries (F_1's and parents) were grown in four rows of 2 m length with spacing of 20 cm X 15 cm transplanted as single seedling/hill. The data was recorded from each cross/genotype in each replication for 11 yield traits *viz*. days to 50% flowering, days to maturity, plant height (cm), effective bearing tillers per plant, panicle length (cm), number of filled grains per panicle, number of unfilled grains per panicle, SPAD Chlorophyll Meter Readings (SCMR), harvest Index (%), test weight (g) and grain yield (g/plant). All the traits were studied on individual plant basis except days to 50% flowering and days to maturity which were recorded on plot basis. All the recommended agronomic and plant protection practices were uniformly applied throughout the crop growth period. The data were subjected to the statistical analysis for analysis of variance as per Panse and Sukhatme (1985) and line x tester analysis as per Kempthorne (1957).

RESULTS AND DISCUSSION

Heterosis expressed as per cent increase or decrease in the mean value of F1 hybrid over mid and better parent are present in the table 1. Days to 50% flowering and grain filling period are the two vital attributes for developing an early maturing variety.

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Hence, negative estimates of heterosis were desirable for this trait. Out of 20 hybrids studied, 10 hybrids exhibited significant negative heterosis over mid parent and 13 hybrids over better parent for this trait. Among which, RNR 2465 x IR 36 (MPH: -11.7, BPH:-14.43) and BPT 5204 x NLR 34449 (MPH: -10.36, BPH: -16.02) exhibited high negative heterosis and these crosses were found to be the best for development of early duration varieties. Panwar (2005) and Veeresha *et al.* (2013) got negative heterobeltiosis for this trait.

For days to maturity the range of heterosis varied from -8.73 (RNR 2465 x IR 36) to 4.06 (BPT 5204 x IR 36) over mid parent and -12.55 (BPT 5204 x NLR 34449) to 1.21 (MTU 1010 x IR 64) over better parent respectively. 14 crosses exhibited significant negative heterosis over mid parent and 14 crosses over better parent. The hybrids *viz.*, BPT 5204 x NLR 34449 (MPH: -7.6, BPH:-12.55), RNR 2465 x IR 36 (MPH: -8.73, BPH:-10.85) and WGL 48684 x NLR 145(MPH:-6.74, BPH: -10.04) recorded high significant negative heterosis estimates over mid and better parent and these crosses were found to be the best crosses for achieving early duration varieties in future. Malini *et al.* (2006) and Singh *et al.* (2007) observed significant negative heterobeltiosis for the trait days to maturity.

Significant increase in rice yield has been achieved with the development of semi dwarf cultivars characterized by lodging resistance, nitrogen responsiveness and erect leaves. Negative values of heterosis and heterobeltiosis were considered desirable for plant height for which the heterosis percent varied from -13.4 (RNR 2465 x NLR 145) to 12.53 (JGL 11118 x IR 36) over the mid parent and -14.11 (RNR 2465 x NLR 145) to 11.48 (JGL 11118 x IR 36) over better parent respectively for this trait. Significant negative heterosis over mid and better parents was observed in the crosses *viz.,* RNR 2465 x NLR 145 (MPH: -13.40, BPH: -14.11), MTU 1010 x IR 64 (MPH: -9.86, BPH: -13.94), MTU 1010 x NLR 145 (MPH:-9.35, BPH: -9.63) and BPT 5204 x IR 36 (MPH:-8.80, BPH:-9.05). Sunil Kumar *et al.* (2012) reported highly significant negative heterosis over better parent and mid parent i.e., in desirable direction.

For the trait number of ear bearing tillers per plant the range of heterosis was from 1.29 to 56.78% over mid parent and from -5.06 to 47.62% over better parent respectively. Heterosis in positive direction is desirable for this trait as more tillers can accommodate more panicles. Twelve crosses recorded significant positive heterosis over better parent and 14 crosses over mid parent. None of the hybrids exhibited significant negative heterosis for both the types. Sharma and Koutu (2013) and Rukmini devi *et al.* (2014) reported both positive and negative mid parent and heterobeltiosis for this trait.

Panicle length is the most important component of grain yield since it bears the sink in rice, more the length of the panicle, it is most often likely to accommodate more number of grains per panicle. In the present study heterosis over mid parent varies from -9.27 % to 22.33% and -10.28 to 17.76% over the better parent respectively. Two hybrids exhibited significant positive heterosis over mid parent and one hybrid over better parent. Among the 20 crosses, JGL 11118 x IR 36 (MPH: 22.33, BPH: 17.76) followed by BPT 5204 x NLR 34449 (MPH: 18.01) recorded high magnitude of heterosis which is desirable. These results were in accordance with the findings of Panwar (2005).

Filled grains per panicle is the ultimate trait which contributes to the maximum grain yield for which, heterosis ranged from -8.88 to 29.58 over mid parent and -16.39 to 12.69 over better parent respectively. Eight crosses recorded significant positive heterosis over mid parent among which MTU 1010 x NLR 34449 (MPH: 29.58) followed by BPT 5204 x IR 64(MP: 28.52) and JGL 11118 x NLR 145 (MPH: 23.92) recorded highest positive significant heterosis. None of the hybrids recorded significant positive heterosis over better parent. High degree of heterosis was revealed by Patil *et al.* (2003) and Pandya and Tripathi (2006), Krishnaveni *et al.* (2005) and Panwar (2005).

Negative significant heterosis is desirable for this trait as less number of unfilled grains is directly proportional to more grain yield. Heterosis for this trait ranged from -25.37 to 38.65 % over mid parent and -32.43 to 24% over better parent respectively. None of the hybrids exhibited significant negative heterosis over mid parent for this trait and three crosses exhibited significant negative heterosis over better parent *viz.*, RNR 2465 x NLR 34449 (-32.43), WGL 48684 x NLR 34449(-26.22) and WGL 48684 x IR 64 (-23.6) and these crosses were considered to be the best crosses for this trait as these crosses recorded less number of unfilled grains per panicle. These findings are in agreement with the earlier findings of Singh *et al.* (2007) over better parent for negative heterosis for this trait.

At flowering stage, the leaf chlorophyll content is directly proportional to total number of filled grains because it coincides with the grain filling stage. However, high leaf chlorophyll content is the desirable feature. Heterosis for SCMR at flowering stage, varied from -7.37 to 16.41over mid parent and -11.18 to 12.87 over better parent respectively. Out of 20 crosses studied, eight crosses over mid parent and three crosses over better parent exhibited significant positive heterosis. JGL 11118 x NLR 145 (MPH: 16.41, BPH: 12.87) recorded high significant positive heterosis followed by RNR 2465 x IR 64 (MPH: 12.06, BPH: 11.03) and BPT 5204 x IR 64 (MPH: 9.58, BPH: 9.13). Among these crosses RNR 2465 x IR 64 and BPT 5204 x IR 64 showed better yield performance as well as high SCMR values. Bhati *et al.* (2015) reported high significant positive heterosis for SCMR readings in rice.

Harvest index directly related to grain yield. Hence positive significant heterosis is desirable for this trait for which the range of heterosis and heterobeltiosis were found to be from –1.04 to 34.62% and from -6.08 to 25.67% respectively. Out of 20 crosses, 12 hybrids recorded significant heterosis over mid parent, nine crosses exhibited significant positive heterosis over better parent. Highest positive significant heterosis exhibited by the cross JGL 11118 x IR 64 (25.67%) over better parent followed by WGL 48684 x IR 64 (24.1), RNR 2465 x IR 64 (23.82%), and BPT 5204 x IR 36 (23.14). Hence, these crosses were considered to be the best for this trait. Positive and negative heterosis for this trait was reported by Adilakshmi and Raghava Reddy (2012) over better parent and mid parent.

Fine grain types fetches more market price and they are generally associated with low test weight for which negative heterosis is considered important. The heterosis ranged from -29.36 to 15.95 over mid parent and -41.35 to 9.79 over better parent respectively. Fifteen crosses each over mid parent and better parent exhibited significant negative heterosis among which RNR 2465 x NLR 145 (MPH: -29.36, BPH: -41.35) followed by WGL 48684 x NLR 145 (MPH:-26.82, BPH:-39.9) and WGL 48684 x IR 36 (MPH: -24.45, BPH: -34.57) exhibited high negative heterosis and these combinations were found to be the best hybrids for attaining fine grain types. Negative heterosis for this trait was already reported by Krishnaveni *et al.* (2005) and Tiwari *et al.* (2011).

The worth of any hybrid is decided by its grain yield. The desirable positive significant heterosis for this trait was exhibited by 15 hybrids over mid parent and 12 hybrids over better parent. The hybrids *viz.*, BPT 5204 x NLR 34449 (MPH: 84.94, BPH: 80.67) followed by BPT 5204 x IR 36 (MPH: 88.96, BPH: 73.91), BPT 5204 x IR 64 (MPH: 89.14, BPH: 78.81) and WGL 48684 x IR 36 (MPH: 63.96, BPH: 63.71) recorded highly significant positive heterosis for the trait grain yield over mid parent and better parent. The genetic basis for such higher manifestation of heterosis over better parent is mainly attributed to dominance (h) and epistatic gene actions of dominance x dominance (l) of complementary nature (both h and l on plus sides). These crosses may be exploited to obtain early desirable segregants for grain yield by restoring pedigree breeding technique. Sanjeev Kumar *et al.* (2008) reported similar results for this trait.

Generally, the heterosis above 15% is considered to be commercially exploitable. It was evident that all the yield contributing traits did not contribute equally towards heterosis for grain yield per plant. This was due to the fact that all the component characters are responsible for sum total of metabolic substances produced by the plant and the conditions which favour the development of one component could have adverse effect on another. Further all the heterotic crosses had close correspondence with the mean value, which suggested that *per se* performance of hybrids could be considered for judging heterosis for grain yield.

Table 1. Estimates of Mid parent Heterosis (MPH), Heterobeltiosis (BPH) for grain yield and yield attributes in rice

S.No	Cross	Days to 50% flowering		Days to maturity		Plant height (cm)		EBTS/plant		Panicle length (cm)	
		MPH	BPH	MPH	BPH	MPH	BPH	MPH	BPH	MPH	BPH
1	BPT 5204 x NLR 34449	-10.36**	-16.02**	-7.60**	-12.55**	8.46*	5.20	47.28**	44.66**	18.01*	12.70
2	BPT 5204 x NLR 145	-2.68	-2.91	-1.11	-1.48	5.70	1.51	28.13**	27.87*	3.26	-9.25
3	BPT 5204 x IR 36	5.15*	-0.97	4.06*	-0.74	-8.80**	-9.05*	39.72**	36.19**	2.59	-7.48
4	BPT 5204 x IR 64	-3.09	-8.74**	-3.68*	-8.12**	-1.69	-2.60	49.89**	45.90**	1.88	-5.47
5	MTU 1010 x NLR 34449	-8.54**	-9.29**	-4.90**	-6.05**	9.21**	2.15	14.52	9.09	7.29	5.64
6	MTU 1010 x NLR 145	-4.12	-9.27**	-3.29*	-7.06**	-9.35**	-9.63**	18.64	15.23	-2.84	-9.69
7	MTU 1010 x IR 36	-2.47	-2.73	-1.62	-2.02	-4.72	-7.98*	34.16**	26.85*	-4.65	-8.88
8	MTU 1010 x IR 64	2.47	2.19	1.62	1.21	-9.86**	-13.94**	34.78**	34.20**	0.00	-1.49
9	JGL 11118 x NLR 34449	-7.87**	-8.89**	-5.39**	-5.79**	2.09	-2.14	48.80**	34.39**	11.11	8.59
10	JGL 11118 x NLR 145	-7.61**	-14.15**	-4.91**	-10.04**	-7.19*	-9.82**	29.75**	19.34	8.24	1.32
11	JGL 11118 x IR 36	-6.70*	-8.24**	-4.94**	-6.10**	12.53**	11.48**	5.86	-5.06	22.33**	17.76*
12	JGL 11118 x IR 64	-4.47	-6.04*	-3.29*	-4.47*	-0.65	-2.74	56.78**	47.62**	-9.27	-9.95
13	RNR 2465 x NLR 34449	-3.74	-7.22**	-3.20*	-6.20**	11.31**	4.61	6.52	0.70	6.37	-0.91
14	RNR 2465 x NLR 145	-7.27**	-9.76**	-5.50**	-7.43**	-13.40**	-14.11**	55.98**	44.72**	-4.04	-5.73
15	RNR 2465 x IR 36	-11.70**	-14.43**	-8.73**	-10.85**	3.30	0.26	1.29	-3.52	8.08	6.85
16	RNR 2465 x IR 64	-6.38*	-9.28**	-5.16**	-7.36**	10.64**	6.15	40.27**	27.18**	9.52	5.02
17	WGL 4868 x NLR 34449	-3.28*	-4.84	0.00	-1.60	-0.21	-4.88	51.43**	46.67**	9.72	6.19
18	WGL 48684xNLR 145	-7.93**	-12.20**	-6.74**	-10.04**	-4.51	-6.68*	23.20*	17.04	3.96	-1.76
19	WGL 48684xIR 36	-3.80	-4.84	-3.23*	-4.00*	-4.09	-5.54	43.45**	40.00**	-7.69	-10.28
20	WGL 48684xIR 64	-2.72	-3.76	-2.42	-3.20	2.07	-0.66	6.99	-0.74	4.22	3.96

** Significant at 1%

* Significant at 5%

Table 2. Estimates of mid parent Heterosis (MPH), Heterobeltiosis (BPH) for grain yield and yield attributes in rice

S.No	Cross	Filled grains per panicle		Un filled grains per panicle		SCMR		Harvest index		Test weight		Grain yield	
		MPH	BPH	MPH	BPH	MPH	BPH	MPH	BPH	MPH	BPH	MPH	BPH
1	BPT 5204 x NLR 34449	4.49	-0.83	-18.38	-18.38	2.51	-2.95	30.49**	18.66**	15.95**	9.79**	84.94**	80.67**
2	BPT 5204 x NLR 145	-4.60	-16.39**	16.94	13.78	-0.52	-2.71	17.06**	4.33	-9.43**	-29.60**	30.90**	10.82
3	BPT 5204 x IR 36	22.56**	6.39	6.17	-7.03	3.75	0.00	34.62**	23.14**	-11.72**	-27.95**	88.96**	73.91**
4	BPT 5204 x IR 64	28.52**	6.39	4.64	-8.65	9.58*	9.13*	29.38**	20.78**	-15.01**	-35.24**	89.14**	78.81**
5	MTU 1010 x NLR 34449	29.58**	8.88	3.97	-15.14	2.61	-0.32	7.44	4.45	-5.36*	-21.94**	44.32**	42.91**
6	MTU 1010 x NLR 145	-3.46	-12.55	-8.90	-24.00	-3.93	-4.36	1.27	-3.67	6.17**	3.81	8.95	-6.70
7	MTU 1010 x IR 36	6.80	-2.26	21.09	11.51	1.16	0.11	4.02	1.77	-10.34**	-14.01**	31.10**	22.19*
8	MTU 1010 x IR 64	7.46	3.81	-16.86	-23.19	4.23	1.90	10.80	10.80	-11.36**	-15.67**	32.41**	26.82**
9	JGL 11118 x NLR 34449	-1.39	-2.54	-17.74	-18.18	11.12**	4.32	25.82**	21.71**	-1.23	-3.87	38.04**	37.43**
10	JGL 11118 x NLR 145	23.92**	12.69	8.29	4.81	16.41**	12.87**	16.20**	10.00	-22.90**	-36.18**	10.63	-4.12
11	JGL 11118 x IR 36	6.71	-3.93	38.65*	20.86	2.23	-2.30	16.88**	13.78*	10.53**	-3.44	17.45*	10.94
12	JGL 11118 x IR 64	15.27*	-1.27	13.85	-1.07	8.90*	7.49	26.31**	25.67**	-26.98**	-40.88**	32.99**	29.14**
13	RNR 2465 x NLR 34449	2.67	1.33	-25.37	-32.43*	-7.37*	-11.18**	10.22	6.71	5.05	1.87	21.79**	7.62
14	RNR 2465 x NLR 145	19.07**	8.13	-16.92	-22.86	2.51	1.58	-0.88	-6.08	-29.36**	-41.35**	35.14**	31.57**
15	RNR 2465 x IR 36	6.40	-4.34	28.72	24.00	10.04*	7.45	12.06*	9.19	-13.85**	-24.49**	1.82	-4.76
16	RNR 2465 x IR 64	19.79**	2.47	4.51	0.33	12.06**	11.03*	24.34**	23.82**	-17.93**	-33.36**	56.83**	42.86**
17	WGL 4868 x NLR 34449	-8.88	-9.92	-12.83	-26.22*	4.43	-2.95	-1.04	-4.53	-19.14**	-20.51**	10.95	4.21
18	WGL 48684xNLR 145	13.06*	2.84	23.98*	2.62	1.41	-2.71	3.97	-1.83	-26.82**	-39.90**	13.40	3.61
19	WGL 48684xIR 36	0.03	-9.92	12.81	-14.23	10.25*	4.27	20.84**	17.31**	-24.45**	-34.57**	63.96**	63.71**
20	WGL 48684xIR 64	12.35	-3.75	0.74	-23.60*	10.67*	8.08	25.08**	24.10**	-17.01**	-33.32**	27.61**	23.83*

** Significant at 1% * Significant at 5%

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Research Article
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FEEDING BEHAVIOUR OF DIFFERENT INDIAN BROWN PLANT HOPPER, *Nilaparvata lugens* (Stal) (Hemiptera: Delphacidae) POPULATIONS ON RESISTANT VARIETIES OF RICE

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ABSTRACT

The virulence levels of different Brown planthopper (BPH) *Nilaparvata lugens* (Stål) populations collected from Ludhiana (Punjab), West Godavari (Andhra Pradesh) and Nalgonda (Telangana) regions of India against popular resistant rice cultivars in terms of honeydew excretion by BPH females were assessed. Populations and varieties have shown significant difference in honeydew excretion where Ludhiana population showed highest honeydew excretion followed by Nalgonda and West Godavari. In the varieties, highest honeydew excretion was noticed on TN1 and lowest on PTB-33.

INTRODUCTION :

The rice brown planthopper (BPH), *Nilaparvata lugens* (Stål) (Hemiptera: Delphacidae), is a typical phloem sap feeder that has emerged as the threat to rice production in Asia (Chen and Cheng, 1978; Normile, 2008; Heong and Hardy, 2009, Sunil *et al.*, 2017). In India, it has emerged as a major pest after 1973 due to the introduction of high yielding short duration fertilizer responsive rice varieties. Recently, BPH has spread to the unconventional areas and most of the rice fields in those areas have shown hopper-burn symptoms sometimes with 100% yield loss. This is due to the injudicious use of fertilizers and insecticides especially synthetic pyrethroids and repeated use of the same insecticide which leads to pest resurgence, insecticide resistance (Jhansi Lakshmi *et al.*, 2010a) and destruction of natural enemies (Jhansi Lakshmi *et al.*, 2010b). Outbreaks of BPH in tropical rice fields have been mainly attributed to the misuse of pesticides that disturbs the natural control of the pest by killing predators and parasitoids (Heinrichs and Mochida 1984). Host plant resistance is the most practical and economical method to tackle this problem (Chelliah, 1985). Mechanisms such as antixenosis and antibiosis often provide basis for resistance in rice varieties against *N. lugens*. Antixenosis is generally expressed in terms of low feeding rate by the planthoppers in many resistant varieties (Song *et al.*, 1972) and measuring honeydew excretion provides a tool for assessing the feeding activity of sucking insects in resistant and susceptible varieties as low honeydew excretion is related to BPH resistance (Nagendra Reddy *et al.*, 2016). The most popular rice varieties, IR 64 and MTU 1010 are moderately resistant to BPH in the adult plant stage. The mechanisms of resistance are not studied in these varieties and the study will aid in incorporating the resistance into the susceptible high yielding varieties. BPH populations from different regions also exhibit variation in their virulence to different cultivars in terms of mechanisms of resistance. Based on the virulence reaction, the resistant variety suitable for that region can be selected. Hence, an attempt was made to study the resistance mechanism in these two cultivars by measuring the honeydew excretion (antixenosis for feeding) of brown planthopper populations collected from different parts of India such as Ludhiana (Punjab), Nalgonda (Telangana) and West Godavari (Andhra Pradesh) along with resistant and susceptible checks viz., PTB33 and TN1 respectively.

MATERIALS AND METHODS

Mass Culturing of BPH

BPH populations were collected from three different areas of the country viz., Ludhiana (Punjab state) with hot semi arid climate representing north-west India where rice crop is grown only during May to September (Wet season); West Godavari District (Andhra Pradesh state) and Nalgonda district

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(Telangana state) with hot sub-humid to semi arid climate in South India where rice is grown in two seasons (Dry and Wet) (agricoop.nic.in). The populations were separately reared on young rice seedlings (cvTN1) using modified Japanese method (Heong *et al.*, 2011) in flexi cages to avoid mating and intermixing of the three populations in the greenhouse at the Indian Institute of Rice Research, Hyderabad, India. The popular cultivated rice varieties resistant to BPH viz., MTU-1010 (unknown genetics) and IR-64 (Bph 1+ gene), along with resistant check PTB-33 (bph2+Bph3+unknown factors) and susceptible check TN-1 were selected and grown and 30 days old plants were used for honeydew excretion test and the experiment was replicated five times.

Measurement of honeydew excretion

The amount of honeydew excreted by the adult hoppers of BPH in selected rice cultivars was measured which is an indication of the feeding preference. Whatman No.1 filter paper was dipped in a 0.02% bromocresol green solution in ethanol and allowed to dry for one hour and dipped again till the filter paper turned yellowish orange (Fig 1). The treated paper was then placed on the wooden plank with a central hole kept at the base of 30-days old plant and a single stem was inserted into the hole of the plastic cup placed over the filter paper. Five freshly emerged female hoppers, pre-starved for 1 hour were released into the plastic cup and the hole was closed with cotton. The BPH adults were allowed to feed for 24 hours at the base of the rice stem. The honeydew droplets excreted by the adults when come into contact with the filter paper turn into blue spots. The area of blue spots appeared on filter paper as a result of honeydew excretion was measured by using ImajeJ software. The xylem spots (light white spots) and phloem spots (blue spots) were measured separately and the data analysis was done by using Analysis of variance (ANOVA) and statistix 8.1 software. The preference/ non-preference for feeding among the rice varieties was determined by comparing the average area of honeydew excreted in mm^2.

RESULTS & DISCUSSION

The results revealed that there was significant difference among the three populations in the amount of honeydew excreted in different varieties with varying levels of resistance (Table 1 and Fig 2). Among the populations, total honeydew excretion was more in Ludhiana population (88.0 mm^2) followed by Nalgonda (86.8 mm^2) and West Godavari (65.9 mm^2) populations. Among the varieties, significantly lowest honeydew excretion was noticed in the resistant PTB-33 (18.7 mm^2) and highest in the susceptible TN1 (200.7 mm^2). In the moderately resistant cultivars *viz.*, IR-64 and MTU-1010, the area of honeydew excretion was 30.7 mm^2 and 58.9 mm^2 respectively. Xylem spots which are faint white in colour were found on the honeydew paper and these were measured separately. The area of xylem spots on different resistant varieties was 9.5 mm^2 on PTB-33, 10.3 mm^2 on IR-64 and 7.2 mm^2 on MTU-1010. There were no xylem spots in the susceptible variety TN1. In West Godavari population, lower area of phloem sap (8.4mm^2) and higher area of xylem sap (9.1 mm^2) was observed on PTB-33. Similarly in MTU-1010 almost equal area of phloem (13.6 mm^2) and xylem spots (10.2 mm^2) were observed whereas in IR-64 higher area of Phloem (20.1 mm^2) and lower xylem sap (3.2 mm^2) were recorded. It is observed that higher phloem sap was recorded on

Fig. 1. Honeydew experimental set up and honeydew spots by feeding of BPH

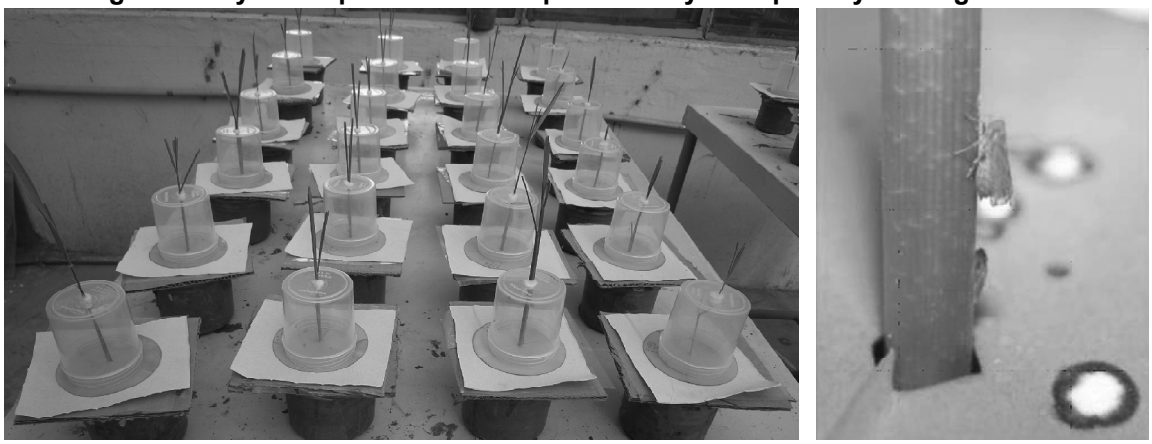

Table 1. Honeydew excretion by female adults of BPH populations on different rice genotypes

BPH populations	Resistant varieties	Area of Phloem spots mm²	Area of Xylem spots mm²	Total Honeydew excreted mm² (phloem+xylem)
West Godavari	MTU1010	13.6±3.2	10.2±4.6	23.8±2.2b
	PTB-33	8.4±1.2	9.1±1.1	17.5±1.4b
	IR-64	20.1±1.5	3.2±0.7	23.3±1.8b
	TN1	199.1±17.6	0	199.1±17.6a
Ludhiana	MTU1010	95.4±44.3	8.5±3.5	103.9±43.8ab
	PTB-33	32.8±14.5	13.4±3.1	46.2±15.4b
	IR-64	52.8±18.6	22.1±5.3	74.9±20.3ab
	TN1	153.2±12.2	0	153.2±12.2a
Nalgonda	MTU1010	67.7±26.2	3.1±0.9	70.8±26.3b
	PTB-33	15.0±3.4	5.9±3.1	20.9±6.3b
	IR-64	19.0±6.0	5.7±1.6	24.6±7.2b
	TN1	230.8±20.2	0.0	230.8±20.2a
CD (0.05) interactions	2.98			
Resistant varieties	MTU1010	58.9±18.3	7.2±2.0	66.1±18.1b
	PTB-33	18.7±5.4	9.5±1.6	28.2±6.2c
	IR-64	30.7±7.4	10.3±2.8	41.0±9.2bc
	TN1	200.7±13.1	0	200.7±13.1a
	CD (0.05) varieties	1.67		
Populations	West Godavari	60.3±8.9	5.6±1.5	65.9±18.1b
	Ludhiana	75.8±16.5	12.2±2.6	88.0±15.8a
	Nalgonda	83.1±21.6	3.7±1.0	86.8±21.1ab
CD (0.05) populations	1.62			

susceptible variety TN1 (199.1 mm²) and on which no xylem spots were observed. In Ludhiana population, significantly higher amount of honeydew excretion was recorded on susceptible variety TN1 (153.2 mm²) and lower on PTB-33 (32.8 mm²). However, no significant difference was observed in moderately resistant varieties MTU-1010 (95.4 mm2) and IR-64 (52.8 mm²). The amount of xylem spots were also observed in almost all resistant varieties viz., IR-64 (22.1 mm²), PTB-33 (13.4 mm²), MTU-1010 (8.5 mm²). In Nalgonda population significantly highest phloem sap was observed on TN1 (230.8 mm²) followed by MTU-1010 (67.7 mm²) IR-64 (19.0 mm²), PTB-33 (15.0 mm²). Similarly xylem spots were observed on resistant varieties viz., PTB-33 (5.9 mm²), IR-64 (5.7 mm²) and MTU-1010 (3.1 mm²). In general, the amount of honeydew excreted by BPH is directly related to the intake of plant sap. Therefore, the amount of honeydew excreted by the insect in unit time when fed on different rice varieties is considered as an index for its feeding preference. In our results, among the rice genotypes significant differences were observed with lower

honeydew in PTB-33 and higher in TN1. Similar results were observed by Vasantha Bhanu *et al*. (2014) with lower amount of honeydew excretion in PTB-33 (79 mm^2) and higher in susceptible variety TN1 (1461 mm^2). In the present study, lower honeydew excretion area in PTB-33, IR 64 and MTU 1010 indicates the non-preference for feeding. The little sap intake or lower honeydew excretion area might be due to the presence of certain undesirable gustatory factors that block the sustained sucking by the insect. When the phloem sap is not suitable for feeding, the insect shifts to the xylem. In the resistant varieties, xylem feeding was observed in all the populations but in susceptible TN1 variety, no xylem feeding was observed. This indicates that the BPH was able to feed on phloem sap in TN1 but there was some inhibition for phloem sap sucking in resistant varieties and it switched to xylem. Similar results were observed by Jena *et al*. (2017) where they observed most of the pyramided NILs having two to three gene combinations showed higher consumption of xylem sap and reduced consumption of phloem sap compared with the NILs having single R genes. This result indicated that BPH cannot feed normally on these pyramided NILs; hence, these NILs were highly resistant. In West Godavari population, higher xylem spots and lower phloem sap on PTB-33 indicated that Bph 2 + Bph 3 combined genes showed an increased level of resistance. Similarly Jena *et al*. (2017) recorded that NIL-*BPH 4* + NIL-*BPH 26* has a high consumption of xylem sap and minimal consumption of phloem sap in the Laguna BPH colony, with an excreted area of 52 mm^2, compared with NIL-*BPH4* and NIL-*BPH26* alone having an excreted area of 675 and 587 mm^2, respectively.

Moreover, *N.lugens* feed less and excretes less honeydew when feeding on rice plants deficient in nitrogen (Sogawa, 1982). Sakai and Sogawa (1976) observed that certain amino acids, sucrose, and organic acids act as feeding stimulants. Low concentrations of asparagine may deter extended feeding (Sogawa and Pathak, 1970). Therefore, amino acid content could vary between rice varieties, and differences in planthopper performance on different varieties were observed.

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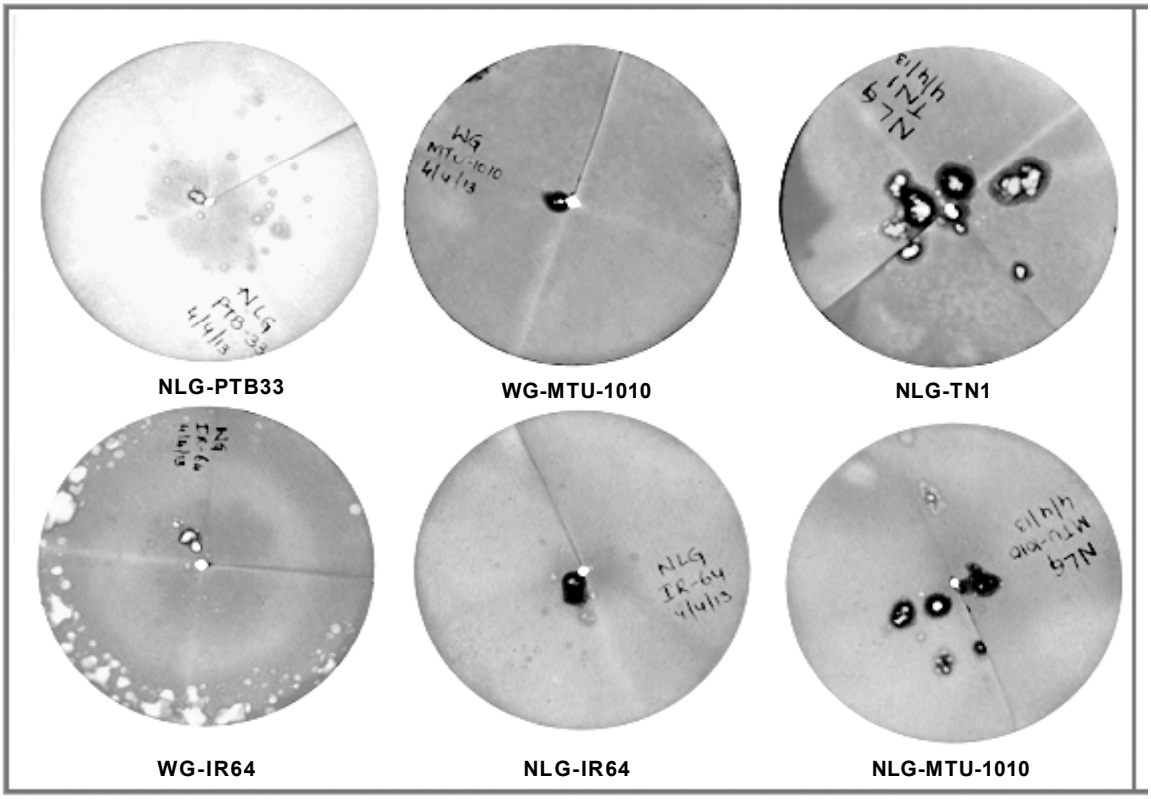
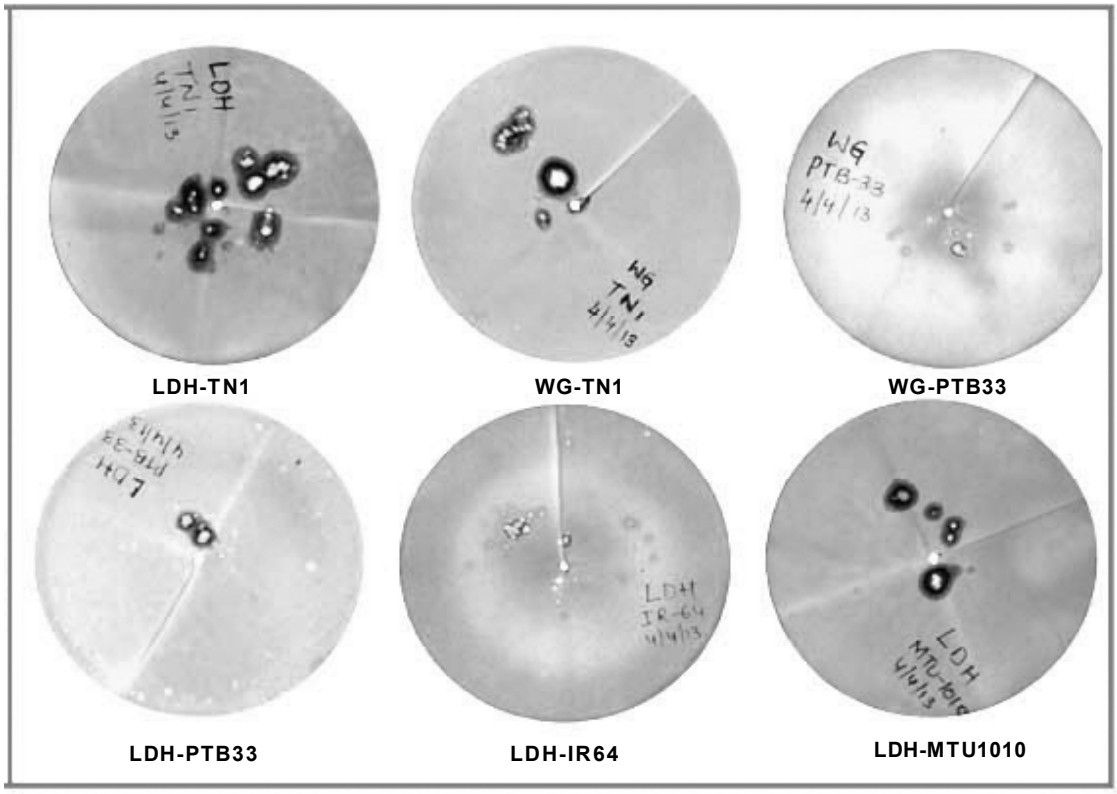
Fig. 2. Honeydew excreted by different adult BPH populations on resistant rice varieties





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Research Article
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COMPATIBILITY OF CERTAIN INSECTICIDES AND FUNGICIDES IN THE MANAGEMENT OF SUCKING PESTS AND LATE LEAF SPOT IN GROUNDNUT

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ABSTRACT

Six insecticides and two fungicides at recommended concentrations were evaluated as tank mix in various insecticide and fungicide combinations for their efficacy against sucking insects pests *viz*., thrips, leafhopper and late leaf spot in groundnut during *Kharif* 2014. Slight phytotoxic (chlorosis) symptoms were seen in combination treatments of imidacloprid + mancozeb + carbendazim and monocrotophos + mancozeb + carbendazim with phytotoxicity score of 1 (0 to 10%) only at recommended dose. The chemical compatibility of insecticide and fungicide combinations measured through the bio-efficacy studies under field conditions revealed that the insecticides, spinosad and thiomethaxam were effective against thrips; thiomethaxam and acetamiprid were effective against leafhopper and their combination with fungicides in no way undermined the efficacy when mixed indicating their compatibility. Similarly the fungicides, mancozeb and carbendazim registered the same efficacy with respect to late leaf spot disease (31-40% disease severity) alone and in combination with other insecticides. The dry pod yields are also highest in insecticide and fungicide combinations (578.7 to 1064.8 kg ha^{-1}) compared to insecticides (555.6 to 995.4 kg ha^{-1}) or fungicides alone (486.1 to 532.4 kg ha^{-1}) and untreated control (416.7 kg ha^{-1}). Thus all the insecticides and fungicides used in the present investigation are compatible with each other and can be combined as tank mix for control of groundnut pests.

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is one of the main oilseed crop of India and it ranks second in the world in production. Groundnut of late was subjected to attack by more than 100 species of insect pests and many diseases at different stages of crop growth and form the important constraints in its production. The sucking insect pest complex comprising thrips and leafhoppers are the major pests of importance (David and Ramamurthy, 2011), while late leaf spot is the most widely distributed and economically important foliar disease causing severe damage to the crop (Reddi Kumar *et al*., 2014). The total yield loss due to insect pests was estimated as 40.2% (Baskaran and Rajavel, 2013) and yield loss of 15-70 per cent is reported due to leaf spot, rust and stem rot singly or in combination in groundnut (Adiver, 2003).

The fluctuations in pest and disease incidence vary from season to season and at different environments. To safeguard the crop, farmers are regularly going for combination of insecticides and fungicides for reducing labour cost, labour shortage and as a measure of economy. The knowledge about compatibility of insecticides and fungicides is very vital in selecting the compatible combination for effective management of insect pests and diseases and also to avoid problems which may arise from combination of some pesticides. Pesticide combinations may show physical, chemical or phytotoxic incompatibility causing undesirable results. Keeping this in view, the present study was undertaken with certain commonly used insecticides and fungicides to find their efficacy on thrips, leafhopper and late leaf spot in groundnut as well as for testing their compatibility.

MATERIAL AND METHODS

Field studies were conducted to evaluate the compatibility and bio-efficacy of certain insecticides and fungicides alone and in combination against sucking pests like thrips, leafhopper and late leaf spot in groundnut during *Kharif* 2014 at Agricultural Research Station, Darsi, Prakasam District, Andhra Pradesh. Six insecticides *viz*., imidacloprid 17.8 SL, acetamiprid 20 %SP, thiamethoxam 25% WG, spinosad 45 SC, monocrotophos 36 SL, acephate 75 WP and two fungicides *viz*., mancozeb 75 WP and carbendazim 50 WP were evaluated in Randomized Block Design (RBD) with 15 treatments as tank mix of insecticide and fungicide combinations including control and

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replicated thrice to evaluate the bio-efficacy and to investigate their compatibility as tank mix application. K6 variety of groundnut was sown in plots of 1.8 m x 4.0 m size maintaining the spacing of 30 cm between rows and 10 cm from plant to plant. All the recommended agronomic package of practices were followed to raise the crop. The treatments were imposed in trial plots twice during the cropping period at 27 and 55 days after sowing.

Plant damage by thrips feeding based on 10 plants in each plot were recorded as percent damaged plants (plants having thrips feeding scars) and percent damaged leaves (leaves on main stems showing thrips feeding damage) at 5, 10, 15 and 20 days after application of treatments. Percentage of damaged leaves was recorded based on percentage of leaves showing visible scars on main stems of 10 plants in each plot. In each leaf, a single leaflet or more in a petiole having scars of thrips feeding was considered damaged. Thrips damage ratings of 1-9 were given to 10 individual plants in each plot, with 1 = no damage to damage 10%, 3 = damage 11-30%, 5 = damage 31-50%, 7 = damage 51-70% and 9= damage 71-100% (Ekvised *et. al.*, 2006). Observations on the population of leaf hoppers were recorded on top three leaves for both the sprays. Pre-treatment observation was made a day before application, while post-treatment observations made 5 and 10 days after application.

Damage severity of late leaf spot disease was recorded during harvesting stage based on standard description (Subramanyam *et al.*, 1995) and disease scoring was done using modified 9- point scale (1-9). Phytotoxicity symptoms on plants were recorded one week after imposition of treatments. Observations for specific parameters like chlorosis, necrosis, wilting, vein clearing, hyponasty and epinasty were taken using the 0-9 scale as 0 - No phytotoxicity; 1 – 0 to 10%, 2 – 11 to 20%, 3 – 21 to 30%, 4 – 31 to 40%, 5 – 41 to 50%, 6 – 51 to 60%, 7 – 61 to 70%, 8 – 71 to 80%, 9 – 81 to 90%, 10 – 91 to 100% phytotoxicity. The recorded data corresponding to each treatment was subjected for statistical analysis after suitable transformation. After the crop attained maturity, it was harvested, pods and haulms were separated in each treatment, dried properly and pod and fodder yields were recorded on mean 10 plants. Plot wise yield was computed on hectare basis for statistical interpretations.

RESULTS AND DISCUSSION

From the table 1 it is evident that the little phytotoxic (chlorosis) symptoms were seen in combination treatments of imidacloprid + mancozeb + carbendazim and monocrotophos + mancozeb + carbendazim with phytotoxicity score of 1 (0 to 10%) only at recommended dose. No phytotoxicity symptoms were observed in any of the rest insecticide and fungicide combinations at recommended dose. Similar results were also reported Kennedy *et al.* (1992) for the control of groundnut insect pests and diseases by application of carbendazim (0.05%) + macozeb (0.2%) + monocrotophos (0.05%) at pre-flowering and post flowering stage. Slight phytotoxic symptoms were also reported in imidachloprid + carbendazim, and monocrotophos + carbendazim combinations when applied on groundnut at recommended (10.0 and 7.14%) and double doses (18.8 and 10.7%, respectively) for the management of late leaf spot and rust diseases (Reddi Kumar *et al.*, 2014).

The per cent thrips damaged leaflets were uniform and the treatments did not show any significant difference a day before spray. The mean foliage damage after two sprays was found varying from 4.3 to 61.1 per cent. Significantly lowest foliage damage by thrips (4.33 per cent) was recorded in the treatment of spinosad and it was at par with thiomethaxam (9.83 per cent) with thrips damage rating of 1. Similar results on the efficacy of thiomethaxam against thrips in groundnut were also reported by Khanpara *et al.* (2016) and Jayewar *et al.* (2017). When insecticides were tank mixed with fungicides, spinosad + mancozeb + carbendazim (4.5%), thiomethaxam + mancozeb + carbendazim (10.27%) and acetamiprid + mancozeb + carbendazim (11.67%) combinations at recommended dose were found to be superior to acetamiprid (15.87%) which recorded a damage rating of 3. Tank mixing of acephate with mancozeb and carbendazim resulted in 16.77 per cent damaged leaflets over individual application of acephate (18.67%). The next best insecticide and fungicide combinations in reducing thrips foliage damage were imidachloprid + mancozeb + carbendazim (22.7%) and monocrotophos + mancozeb + carbendazim (27.37%) and were at par with application of imidachloprid (23.87%) and monocrotophos (24.33%) alone. Maximum mean foliage damage of 61.1 per cent was recorded in

untreated control with damage rating of 7 which is at par with macozeb (55.53%) and carbendazim (60.6%).

The mean leafhopper population before spray was ranged from 12.7 to 17.7 hoppers leaves^{-3} plant^{-5} suggesting uniform distribution among treatments and it was found to be non-significant. The overall mean leafhopper population from all treatments after two sprays ranged from 5.7 to 33.3 hoppers leaves^{-3} plant^{-5} and it differed significantly within the treatments. The lowest overall mean leafhopper population (5.67 leaves^{-3} plant^{-5}) was recorded in the treatment, thiomethaxam followed by thiomethaxam + mancozeb + carbendazim (6.33 leaves^{-3} plant^{-5}) which were at par with each other and differed significantly with that of rest of the chemical treatments. The efficacy of thiamethaxam in controlling the leafhopper is in conformity with the observations recorded on groundnut by Jayewar *et al*. (2017). The treatments which showed on par results with the former were acetamiprid (7.0 leaves^{-3} plant^{-5}), acetamiprid + mancozeb + carbendazim (8.0 leaves^{-3} plant^{-5}), imidachloprid, monocrotophos (9.0 leaves^{-3} plant^{-5}, each), acephate (9.33 leaves^{-3} plant^{-5}), acephate + mancozeb + carbendazim (10.33 leaves^{-3} plant^{-5}), imidachloprid + mancozeb + carbendazim (10.67 leaves^{-3} plant^{-5}) and monocrotophos + mancozeb + carbendazim (11.67 leaves^{-3} plant^{-5}). These treatments were followed by spinosad (14.33 leaves^{-3} plant^{-5}) and the efficacy was not reduced when it was tank mixed with mancozeb + carbendazim (16.33 leaves^{-3} plant^{-5}). The highest overall mean leafhopper population was recorded in mancozeb (27.33 leaves^{-3} plant^{-5}), carbendazim (28.67 leaves^{-3} plant^{-5}) and untreated control (33.33 leaves^{-3} plant^{-5}) which were on par.

When fungicides alone were evaluated against late leaf spot disease carbendazim recorded a damage score of 5.6 followed by mancozeb with a score of 5.9 (31-40 per cent disease severity). The fungicide and insecticide combinations registered the same efficacy with respect to late leaf spot disease similar to that of fungicides alone and did not altered the efficacy of fungicides except acephate when tank mixed with mancozeb and carbendazim which recorded a damage score of 6.7 (41-60 per cent disease severity) . Hence, all the test combinations in the study were compatible with each other for spray application in groundnut to control the defoliator pests and tikka leaf spot. Lowest per cent late leaf spot disease intensity was also reported in combination treatments of difenconazole + monocrotophos (Vijaya Bhaskar *et al*., 2012).

There was a significant difference between the treatments for pod yields (Table 2) and all the plots treated with combination of insecticides and fungicides recorded higher dry pod yields (578.7 to 1064.8 kg ha^{-1}) compared to individual application of insecticides (555.6 to 995.4 kg ha^{-1}) and fungicides alone (486.1 to 532.4 kg ha^{-1}) and also untreated control (416.7 kg ha^{-1}) due to less damage caused by the target insects and diseases. Similar trend was also observed in obtaining higher dry haulm yields by combination treatments.

CONCLUSION

From the present study it was evident that tank mixing of insecticides with fungicides at recommended dose did not reduce the efficacy of combination against thrips, leafhopper and late leaf spot. Hence, they are compatible with each other for spray application to control sucking pests and diseases in groundnut.

Table 1. Bio efficacy of insecticide and fungicide combinations against sucking pests and late leaf spot of Ground nut during *Kharif*, 2014

Treatments	Phyto Toxicity score (0-9 scale)	*Thrips damaged leaflets (%)		**Mean no. of nymphs and adult hoppers leaves^{-3} plant^{-5}			Late leaf spot damage score (1-9 scale)	% Disease severity
		Pre treatment	Post treatment (Mean of two sprays)	Thrips damage rating	Pre treatment	Post treatment (Mean of two sprays)rating		
Imidacloprid 17.8 SL @ 0.4 ml lt^{-1}	0	14.27(22.16)	23.87(29.18)	3	12.67(3.69)	9.00(3.15)	7.8	61-80
Acetamiprid 20% SP @ 0.2 g lt^{-1}	0	14.30(22.21)	15.87(23.40)	3	14.33(3.89)	7.00(2.81)	8.1	61-80
Thiamethoxam 25% WG @ 0.2 g lt^{-1}	0	12.57(20.68)	9.83(18.26)	1	14.67(3.95)	5.67(2.57)	7.6	61-80
Spinosad 45SC @ 0.4 ml lt^{-1}	0	10.57(18.94)	4.33(11.90)	1	15.67(4.08)	14.33(3.91)	7.7	61-80
Monocrotophos 36 SL @ 1.6 ml lt^{-1}	0	14.47(22.34)	24.33(29.56)	3	14.67(3.95)	9.00(3.16)	7.2	41-60
Acephate 75 WP @1.5 g lt^{-1}	0	14.40(22.20)	18.67(25.60)	3	14.00(3.86)	9.33(3.21)	7.3	41-60
Mancozeb 75 WP @ 2.5 g lt^{-1}	0	14.70(22.52)	55.53(48.21)	7	15.33(4.03)	27.33(5.31)	5.9	31-40
Carbendazim 50 WP @ 1.0 g lt^{-1}	0	17.80(24.81)	60.60(51.15)	7	14.67(3.95)	28.67(5.44)	5.6	31-40
Imidacloprid @ 0.4 ml lt^{-1} + Mancozeb @ 2.5 g lt^{-1} + Carbendazim @ 1.0 g lt^{-1}	1	15.37(23.00)	22.70(28.44)	3	14.00(3.84)	10.67(3.40)	6.4	31-40
Acetamiprid @ 0.2 g lt^{-1} + mancozeb @ 2.5 g lt^{-1} + carbendazim @ 1.0 g lt^{-1}	0	13.00(21.03)	11.67(19.97)	3	14.33(3.91)	8.00(2.99)	6.1	31-40
Thiamethoxam @ 0.2 g lt^{-1} + mancozeb @ 2.5 g lt^{-1} + carbendazim @ 1.0 g lt^{-1}	0	11.77(20.06)	10.27(18.69)	1	13.67(3.82)	6.33(2.70)	6.0	31-40

Treatments	Phyto Toxicity score (0-9	*Thrips damaged leaflets (%)		**Mean no. of nymphs and adult hoppers leaves^{-3} plant^{-5}			Late leaf spot damage score (1-9 scale)	% Disease severity
		Pre treatment	Post treatment (Mean of two sprays)	Thrips damage rating	Pre treatment	Post treatment (Mean of two sprays)rating		
Spinosad @ 0.4 ml lt^{-1} + mancozeb @ 2.5 g lt^{-1} + carbendazim @ 1.0 g lt^{-1}	0	12.40(20.54)	4.50(12.23)	1	16.33(4.16)	16.33(4.16)	5.9	31-40
Monocrotophos @ 1.6 ml lt^{-1} + mancozeb @ 2.5 g lt^{-1} + carbendazim @ 1.0 g lt^{-1}	1	19.33(26.01)	27.37(31.55)	3	15.67(4.07)	11.67(3.55)	6.3	31-40
Acephate @ 1.5 g lt^{-1} + mancozeb @ 2.5 g lt^{-1} + carbendazim @ 1.0 g lt^{-1}	0	16.07(23.58)	16.77 (24.18)	3	17.00 (4.23)	10.33 (3.36)	6.7	41-60
Untreated Check	0	15.87(23.47)	61.10(51.46)	7	17.67(4.31)	33.33(5.84)	8.8	81-100
SEM ±		**1.36**	**0.99**		**0.16**	**0.15**		
CD (P=0.05)		**NS**	**2.87**		**NS**	**0.44**		
CV%		**10.6**	**6.1**		**7.2**	**7.2**		

0 - No phytotoxicity; 1 – 0 to10% Phytotoxicity, 2 – 11 to 20%, 3 – 21 to 30%, 4 – 31 to 40%, 5 – 41 to 50%, 6 – 51 to 60%, 7 – 61 to 70%, 8 – 71 to 80%, 9 – 81 to 90%, 10 – 91 to 100% phytotoxicity

Thrips damage rating: 1- no damage to damage 10%; 3- Damage 11-30%; 5 – Damage 31- 50%; 7 – Damage 51-70%; 9- Damage 71-100% (Ekvised *et. al.*, 2006)

*Figures in parenthesis are arc sign transformed values

**Figures in parenthesis are square root transformed values

Table 2. Effect of insecticide and fungicide combinations on the yields of Ground nut evaluated during *Kharif*, 2014

Treatments	No of pods plot^{-1}	Avg. Pt. std. plot^{-1} at harvest	Dry pods (kg ha^{-1})	Haulms (kg ha^{-1})
Imidacloprid 17.8 SL @ 0.4 ml lt^{-1}	16.0(4.12)	207.3(14.43)	717.6(26.75)	4467.2(66.71)
Acetamiprid 20% SP @ 0.2 g lt^{-1}	17.4(4.28)	214.3(14.67)	833.3(28.86)	5274.6(72.51)
Thiamethoxam 25% WG @ 0.2 g lt^{-1}	17.5(4.30)	198.7(14.12)	925.9(30.30)	5487.0(74.03)
Spinosad 45SC @ 0.4 ml lt^{-1}	16.0(4.11)	219.3(14.84)	995.4(31.56)	6478.1(80.41)
Monocrotophos 36 SL @ 1.6 ml lt^{-1}	17.5(4.30)	190.3(13.82)	555.6(23.35)	4012.2(63.25)
Acephate 75 WP @1.5 g lt^{-1}	17.3(4.27)	198.0(14.10)	740.7(27.15)	4548.0(67.43)
Mancozeb 75 WP @ 2.5 g lt^{-1}	17.6(4.29)	125.3(11.18)	532.4(22.87)	2964.7(54.14)
Carbendazim 50 WP @ 1.0 g lt^{-1}	15.4(4.04)	127.0(11.31)	486.1(22.07)	3092.5(55.51)
Imidacloprid @ 0.4 ml lt^{-1} + Mancozeb @ 2.5 g lt^{-1} + Carbendazim @ 1.0 g lt^{-1}	16.2(4.14)	210.3(14.53)	671.3(25.11)	5681.9(75.37)
Acetamiprid @ 0.2 g lt^{-1} + mancozeb @ 2.5 g lt^{-1} + carbendazim @ 1.0 g lt^{-1}	15.7(4.09)	201.0(14.21)	833.3(28.81)	4909.1(70.05)
Thiamethoxam @ 0.2 g lt^{-1} + mancozeb @ 2.5 g lt^{-1} + carbendazim @ 1.0 g lt^{-1}	16.3(4.15)	221.7(14.92)	925.9(30.38)	4731.9(68.77)
Spinosad @ 0.4 ml lt^{-1} + mancozeb @ 2.5 g lt^{-1} + carbendazim @ 1.0 g lt^{-1}	21.9(4.78)	227.7(15.11)	1064.8(32.59)	7901.0(88.59)
Monocrotophos @ 1.6 ml lt^{-1} + mancozeb @ 2.5 g lt^{-1} + carbendazim @ 1.0 g lt^{-1}	14.3(3.90)	193.7(13.95)	578.7(23.94)	4363.0(66.00)
Acephate @ 1.5 g lt^{-1} + mancozeb @ 2.5 g lt^{-1} + carbendazim @ 1.0 g lt^{-1}	17.7(4.32)	195.3(14.01)	694.4(26.28)	4957.0(70.24)
Untreated Check	11.5(3.51)	124.0(11.17)	416.7(20.24)	2507.5(50.06)
SEM ±	**0.14**	**0.25**	**1.91**	**2.66**
CD (P=0.05)	**0.42**	**0.75**	**5.54**	**7.7**
CV%	**6.0**	**3.3**	**12.4**	**6.8**

Values in Parenthesis are SQRT (X+1) values

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Research Article
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PERCEPTION OF THE FARMERS ON ZERO BUDGET NATURAL FARMING IN PRAKASAM DISTRICT OF ANDHRA PRADESH

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ABSTRACT

The study investigated farmers' perception on Zero Budget Natural Farming (ZBNF) in Prakasam District of Andhra Pradesh with the specific objectives of assessing over all farmers' perception, the determinants of their perception, sources of information for ZBNF, constraints in practicing ZBNF and suggestions for sustainable ZBNF adoption. Sixty farmers practicing ZBNF were purposively selected from ten ZBNF clusters of Prakasam District. The data collected were analyzed using frequency counts, percentages and correlation analysis. Majority (65.00%) of the farmers had medium perception on ZBNF followed by high (18.33%) and low (16.67%). Great majority (86.67%) of the farmers agreed that soil will be enriched with ZBNF, quality production is possible with ZBNF, ZBNF increases micro organisms and earth worms in soil (80.00%), facilitates natural enemies population (68.33%), is complex to adopt (63.33%), weed management is difficult (55.00%) and ZBNF is difficult to practice (53.33%). But they have disagreed that adoption of ZBNF on large scale is possible (55.00%) and purchasing and maintaining traditional cows is difficult (51.67%). The major sources of information were trainings attended by the farmers on ZBNF (91.67%), Community Resource Persons (90.00%), Department of Agriculture (88.33%), practicing farmers (73.33%) and through television (51.67%). Trainings undergone, ZBNF experience, innovativeness, education and extension contact were the variables having highly significant positive relation with farmers' perception at 0.01% level. The major constraints expressed by the practicing ZBNF farmers were non availability of ZBNF inputs (81.67%), lack of information on preparation and use of asthras (76.67%), low yields in initial years (75.00%), weed management (68.33%), preparation of asthras is difficult (63.33%) and intensive labour requirement (53.33%). The ZBNF farmers have suggested that creating awareness among farmers (78.33%), application of asthras through fertigation (71.67%), making ZBNF inputs locally available (63.33%) providing market support for ZBNF produce (58.33%) and giving wide publicity on the benefits of ZBNF (51.67%) would facilitate its large scale adoption.

INTRODUCTION

Before 1940's, when the population was smaller than it is today, it was common for farmers throughout the world to grow organic food, and yields were similar to that of prehistoric times. The farmers focus was on growing enough food to feed themselves and their families. However, as the world's population increased, growing organic food was no longer a feasible way to feed the society. This had led to the introduction of intensive technologies, including more efficient ways to feed the population that had almost doubled in size. Fertilizers, mechanized cultivation, biocides such as pesticides and herbicides, helped in producing greater yields for the larger population. These farming practices became integral part of what we know as conventional farming (Melissa, 2003). The Green revolution promoted use of new and high yielding varieties of crops that depend on agrochemicals to produce higher yields. These new varieties were often susceptible to insect pests and diseases and hence insecticides and fungicides had to be introduced to combat them.

The consequences of green revolution were reviewed and found that it has led to reduced genetic diversity, increased vulnerability to pests, enhanced soil erosion and water shortages, reduced soil fertility, micronutrient deficiencies, increased soil contamination, reduced availability of nutritious food crops for the local population, the displacement of vast numbers of small farmers from their land, rural impoverishment and increased tensions and conflicts. The beneficiaries of the green revolution have been the agrochemical industries, large petrochemical companies, manufacturers of agricultural machinery, dam builders and large landowners (Greenpeace, 2003). Therefore, an alternative agriculture and agro ecological methods could apply which can function in an ecosystem friendly while sustaining and increasing the crop productivity

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and also concerning about health promotion in the community. In this search for eco friendly and farmer friendly alternate systems of farming, Subhash Palekar's Zero Budget Natural Farming is increasingly becoming popular among the farming community. The state government of Andhra Pradesh made considerable efforts in this regard with cluster approach to demonstrate and train farmers on Zero Budget Natural Farming through the Department of Agriculture. In each district 10 clusters were identified to train farmers on ZBNF with selected Community Resource Persons (CRPs). However, some farmers succeeded in shifting to ZBNF, while others remained in chemical based farming systems. This might be due to low levels of perception and adaptation to ZBNF. Therefore an attempt was made in the present study to analyze the perception of the practicing farmers on ZBNF with the following specific objectives,

1. To analyze the perception of the farmers on ZBNF (Zero Budget Natural Farming)
2. To study the ZBNF sources of information for the farmers
3. To assess the relationship between profile characteristics of farmers and their perception on ZBNF
4. To elicit constraints and offer suggestions for ZBNF

MATERIAL AND METHODS

The present investigation was carried out in Prakasam district of Andhra Pradesh during the year 2016-17. About Sixty ZBNF practicing farmers from 10 different clusters identified by the Department Of Agriculture were purposively selected for the study purpose. From each cluster 6 farmers who were fully adopting ZBNF recommended package were selected, thus making the final sample size 60. To analyze the perception of the farmers on ZBNF, a schedule was constructed with 16 statements on three point continuum i.e., Agree, Undecided and Disagree and scores of 3, 2 and 1 were assigned to the responses accordingly for positive statements and for negative statements 1,2 and 3 scores were given. Correlation analysis was carried out to assess the relationship between profile characteristics of farmers and their perception on ZBNF. Each ZBNF practicing farmer was also interviewed by posing open ended questions so as to unearth sources of information, constraints he/she has experienced and suggestions for sustainable ZBNF adoption. The data were collected by using pre tested schedule employing personal interview method. The responses were scored, quantified, categorized and tabulated using mean, standard deviation, frequencies and percentages.

RESULTS AND DISCUSSION

Perception of farmers on Zero Budget Natural Farming

The perception of the farmers on Zero Budget Natural Farming (ZBNF) was analyzed in terms of overall perception of the farmers and item analysis of their perception and the results presented in Table 1 & 2.

Table 1. Overall perception of the farmers on Zero Budget Natural farming

N=60

Perception category	Frequency	%
Low (< Mean-SD)	10	16.67
Medium (Mean+/-SD)	39	65.00
High(>Mean+SD)	11	18.33
	60	**100.00**
Mean= 34.67, SD=3.86		

Table 2. Perception of the farmers on ZBNF N=60

S.No	Perception	Disagree		Agree		Undecided	
		Fre	%	Fre	%	Fre	%
1	ZBNF is relatively advantageous over chemical farming	32	53.33	5	8.33	23	38.33
2	ZBNF gives more net returns	24	40.00	14	23.33	22	36.67
3	ZBNF reduces cost of cultivation to a greater extent	27	45.00	25	41.67	8	13.33

S.No	Perception	Disagree		Agree		Undecided	
		Fre	%	Fre	%	Fre	%
4	ZBNF is feasible to adopt in present farming situation	28	46.67	20	33.33	12	20.00
5	ZBNF is complex to adopt	38	63.33	14	23.33	8	13.33
6	Soil will be enriched with ZBNF	52	86.67	5	8.33	3	5.00
7	ZBNF gives sustainable yields	16	26.67	37	61.67	7	11.66
8	ZBNF facilitates natural enemies population	41	68.33	17	28.33	2	3.33
9	Quality production is possible with ZBNF	48	80.00	10	16.67	2	3.33
10	ZBNF is difficult to practice	32	53.33	13	21.67	15	25.00
11	Preparation of asthras is difficult	24	40.00	16	26.67	20	33.33
12	Adoption of ZBNF on large scale is possible	5	8.33	22	36.67	33	55.00
13	Availability of traditional varieties seed is difficult	21	35.00	19	31.67	20	33.33
14	Weed management is difficult in ZBNF	33	55.00	7	11.67	20	33.33
15	Purchasing and maintaining traditional cows is difficult	22	36.67	7	11.67	31	51.67
16	ZBNF increases micro organisms and earth worms in soil	48	80.00	12	20.00	0	0.00

Majority (65.00%) of the farmers had medium perception followed by high (18.33%) and low (16.67%) on Zero Budget Natural Farming. This is because majority of them agreed that soil will be enriched with ZBNF (86.67%), quality production is possible with ZBNF and it increases micro organisms and earth worms in soil (80.00%), ZBNF facilitates natural enemies population (68.33%), it is complex to adopt (63.33%), weed management is difficult in ZBNF (55.00%), ZBNF is relatively advantageous over chemical farming and is difficult to practice (53.33%), ZBNF reduces cost of cultivation to a greater extent (45.00%), gives more net returns and preparation of asthras is difficult (40.00%). Majority (61.67%) of the farmers were undecided about getting sustainable yields through ZBNF. More than half of the famers disagreed that adoption of ZBNF on large scale is possible (55.00%) and purchasing and maintaining traditional cows is difficult (51.67%). Similar results were reported by Dipeolu *et al.* (2006), Tratnik *et al.* (2009), Oyesola *et al.*(2011) and Suresh and Himansu (2015) with respect to farmers perception on organic farming. Perception of the farmers on ZBNF clearly indicated that even though there were lot many advantages of ZBNF, few aspects like preparation of ZBNF inputs, weed management and inability to practice on large scale need to be addressed to facilitate its large scale adoption by the Government through line departments

Source of Information for ZBNF farmers

It could be inferred from table 3 that trainings on ZBNF were the major source of information for great majority of the farmers (91.67%). This is because the identified cluster farmers were trained through department of Agriculture on a regular basis. Majority (90%) of the farmers had information from community resource persons as they were available locally. The Department Agriculture officials trained the farmers on ZBNF (88.33%), practicing farmers (73.33%) and television (51.67%) were the other major sources of information followed by newspaper (43.33%).

Relationship between profile characteristics of ZBNF farmers and their perception

The perusal of table 4 revealed that trainings undergone, innovativeness, ZBNF experience, education and extension contact were found to have significant positive relation with farmers perception at

0.01% level, whereas farming experience had significant positive relation at 0.05% level. The reason behind this trend may be the trainings undergone on ZBNF, ZBNF experience, innovativeness, education and extension contact facilitated the farmers to gain good knowledge on ZBNF, skills in preparation of asthras and overcoming practical difficulties in ZBNF. Farm size was the variable which had no significant relation with the perception.

Constraints expressed by ZBNF farmers

From table 5, it could be observed that majority (81.67%) eighty two per cent of the ZBNF farmers felt non availability of required inputs was the major constraint for ZBNF. This might be due to risk involved in preparation of various asthras and their preservation. More than three fourth (76.67%) of farmers expressed lack of information on preparation and use of asthras was another constraint hindering them to extend ZBNF on a large scale. Other major constraints expressed by the farmers were low yields in initial years (75.00%), difficulty in weed management (68.33), difficulty in preparation of asthras (63.33%), and intensive labour requirement for preparation of asthras (53.33%). Almost fifty per cent (48.33%) of the farmers felt lack of skills in preparation of asthras was another difficulty. Even though farmers were theoretically trained on ZBNF, they were lacking practical experience in preparation of asthras. Non availability of labour was another threat hindering farmers to adopt ZBNF on large scale.

Suggestions of ZBNF farmers

Suggestions of the farmers for sustainable adoption of ZBNF were presented in table 6. It could be inferred from the table that creating awareness among farmers (78.33%), application of asthras through fertigation (71.67%), making ZBNF inputs available locally (63.33%), providing market support for ZBNF produce (58.33%), giving wide publicity on the benefits of ZBNF (51.67%) and providing trainings to the farmers (43.33%) would facilitate the farmers to adopt ZBNF continuously.

Based on the findings of the study, it can be concluded that the majority of the farmers had medium perception on ZBNF. The farmers had access to information on ZBNF through trainings, community resource persons, departmental officers, practicing farmers and through television. Trainings undergone, innovativeness, ZBNF experience, education and extension contact were found to have significant and positive relation with their perception on ZBNF. The major constraints expressed were non availability of ZBNF inputs, lack of information on preparation and use of asthras, low yields in initial years and weed management. Hence efforts are needed to facilitate farmers with continuous support through series of trainings on technical knowhow to adopt ZBNF.

Table 3. Distribution of ZBNF farmers based on their sources of information

N=60

S.No	Information Source	Fre quency	Per centage
1	Training on ZBNF	55	91.67
2	Community Resource Persons	54	90.00
3	Department of Agricul-ture	53	88.33
4	Practicing farmers	44	73.33
5	Television	31	51.67
6	News Paper	26	43.33

Table 4. Relationship between profile characteristics of farmers and their perception on ZBNF

N=60

S.No	Variable	Correlation coefficient (r)
1	Age	0.18NS
2	Education	0.56**
3	Farming experience	0.21*
4	ZBNF experience	0.67**
5	Farm size	0.10NS
6	Extension contact	0.38**
7	Innovativeness	0.59**
8	Trainings undergone	0.72**

Table 5. Constraints expressed by ZBNF farmers

N=60

S.No	Constraint	Frequency	%
1	Non availability of ZBNF inputs	49	81.67
2	Lack of information on preparation and use of asthras	46	76.67
3	Low yields in initial years	45	75.00
4	Weed management is difficult	41	68.33
5	Preparation of asthras	38	63.33
6	Intensive labour requirement	32	53.33
7	Lack of skills in preparation of asthras	29	48.33

Table 6. Suggestions of ZBNF farmers

N=60

S.No	Suggestion	Frequency	%
1.	Creating awareness among farmers	47	78.33
2.	Application of asthras through fertigation	43	71.67
3.	Making ZBNF inputs available locally	38	63.33
4.	Providing market support for ZBNF produce	35	58.33
5.	Giving wide publicity on the benefits of ZBNF	31	51.67
6.	Providing trainings to the farmers	26	43.33

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Research Article
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EGG PRODUCTION AND EGG QUALITY TRAITS IN RAJASRI BIRDS REARED UNDER SCAVENGING AND OTHER SYSTEMS OF MANAGEMENT

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ABSTRACT

A study was conducted to evaluate the growth and production performance of Rajasri, a synthetic backyard bird during growing and laying period. The birds were reared under different systems of management and feeding regimens, *ad lib* feeding group (T1) reared under intensive system while 20% of *ad lib* (T2) and 40% of *ad lib* (T3) groups were reared under semi-intensive condition and T4 group was reared under scavenging at farmers backyard. The results revealed that the body weight gain was significantly (P<0.05) higher for T_1 group (1085.62g) followed by T_3, T_2 and T_4 groups respectively during growth phase (7-20 weeks). Whereas poorest FCR was recorded in T1 group (6.38) than T2 (3.32) and T3 (4.28) groups. Liveability was significantly (P<0.05) better with intensive system and least with scavenging system. The age at first egg and 50% egg production was significantly better in *ad lib* fed group (146.5d and 165.75d) followed by scavenging group (T4) and much inferior with feed restricted groups (T2 > T3). The mean per cent hen day egg production over 10 laying periods was significantly better with *ad lib*. group (56.83%) and least with 20 and 40% *ad lib* (22.10 and 29.23%). Scavenging at farmer's backyard resulted in 37.81%. The egg weight was significantly inferior with farmer's backyard scavenging system but the yolk colour was significantly (P<0.05) superior when compared to all other treatment groups. Haugh unit score and Albumin index was significantly (P<0.05) high for scavenging fed birds compared to other groups. Shank length was not significantly (P<0.05) influenced by the treatment groups, while Shank pigmentation was significantly (P<0.05) better in scavenging group compared to other groups.

INTROUDCTION

After commercialization of poultry production, the trend and availability of eggs and chicken meat was completely reversed. As a result about 75% of total poultry produce is available for 25% of country's population residing in urban/semi urban areas. A balanced growth in these sectors will ensure nutritional security and economic access to much needed animal protein to millions of needy people (Pica-Ciamarra and Dhawan, 2010). Accordingly certain varieties suitable for backyard farming were developed. They comprised mostly synthetic stocks or crosses of one/two/three breeds. However, employing RIR, WLH, DR and Nondescript native breeds, a 4 breed backcross with 25% native inheritance (Rajasri) was developed by PV Narsimha Rao Telangana Veterinary University, Rajendranagar, Hyderabad to boost the backyard poultry production. Rajasri birds were capable of producing 140-150 eggs per year under scavenging conditions (Srinivas *et al*. 2017). Hence, present study was undertaken to evaluate the growth and production performance of Rajasri birds reared under different systems of management during growing and laying stage.

MATERIAL AND METHODS

A total of 320 female Rajasri growers (7 weeks old) were randomly distributed into 4x4 treatment groups with 20 birds in each replicate. The birds were reared under different systems of management and feeding regimens, *ad lib* feeding group (T1) reared under intensive system while 20% of *ad lib* (T2) and 40% of *ad lib* (T3) groups were reared under semi-intensive condition and T4 group was reared under scavenging at farmers backyard. Under intensive system the birds were fed with corn-soya diet. In semi-intensive system the birds were offered with 500 g of raw Lucerne in addition to concentrate feed under 20 and 40% of *ad lib*. The data on body weight, feed consumption and liveability was recorded bi-weekly while data on egg production was recorded for 10 laying periods of 28 days each. The egg quality parameters were recorded at 40 weeks of age. Statistical analysis was done with one way ANOVA. The significant differences were located using Duncan's multiple Range Test.

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RESULTS AND DISCUSSION

The performance of Rajasri birds were shown in table 1. Body weight gain, feed consumption was significantly higher for *ad lib* fed birds (T1), mainly due to optimum availability of nutrients in (Scott.,1982). In accordance to other findings Shawkat Ali (2002) recorded least growth rate in scavenging than intensive or semi-intensive systems of management. Similarly the highest body weights were recorded in T1 group during growing stage may be attributed to the extent of feed available, which could be utilized for deposition of protein / fat in the body, besides meeting the requirements of egg production. Considering these aspects the highest gain in *ad lib*., is justifiable. The FCR followed a different trend. The best FCR (3.32) was obtained on 20 % *ad. lib.* group followed by 40 % *ad lib.* group (4.28) and the control group recorded significantly poor FCR (6.38).

The average age at first egg was better for extensive system of rearing when compared with 20% and 40% *ad lib* feeding (184.5 and 188 d). The values at field level are comparatively less than the AFE of synthetic layer breed (Girirani) 177 to 174 day as reported by Loknath and Murthy (2002). Similarly, Bhattacharya *et al.* (2005) and Bhat *et al*. (2007) also reported that AFE ranged from 172 to 185 days for Vanaraja breed. The age at 50% hen day egg production followed almost similar trend as that of the age at first egg as shown in table 1. However, the difference between control group and 20% supplementary group further widened to 48.75 days than 38 days as observed with AFE. This may be attributed to high nutrient availability (18g of CP/bird/day) with control than 3.6g of CP/bird/day with 20% supplementation group. Similar results were also reported by Dilip *et al*. (2013).

The best mean percent hen day egg production over 10 laying periods of 28 days each was recorded in T_1 (56.83), because the birds were fed *ad lib* with layer mash containing 18% CP and 2600 Kcal/kg. Significantly ($P<0.05$) least production (22.10%) was observed in T_2, and while increasing the level from 20 to 40% of *ad lib* feeding with Lucerne (T_3) improved the performance (29.23%) but, it was still statistically comparable with T_2. Scavenging at farmer's backyard (37.81%) gave better results. Similarly, Shawkat Ali. (2002) has shown that egg production was significantly higher in ad lib (120 g) fed birds than 30 and 60g supplementation with scavenging and scavenging alone. Similar results were also reported by Srinivas *et al*. (2017) under scavenging conditions.

The average egg weights in this study were 52.60 g *ad lib*., 51.14g at 40% of *ad lib*. and 50.31g in 20% *ad lib*. groups, while scavenging birds recorded mean egg weight of 49.69g (Table 1). The results in present study were similar to that reported by Wani *et al*. (2007), Shawkat Ali (2002) and Naga Raja Kumari and Subrahmanyeswari, (2014). Rahman *et al.* (1998) also observed that *ad lib*. fed groups had highest egg weight followed by 75g of supplementation and 25g supplementation. This may be attributed to variations in body weights, which in turn influenced by the level of feed intake.

Internal egg quality in terms of Haugh unit score was significantly high for scavenging fed birds than 20%, 40% supplementation (Table 1). The finding were in accordance with Shawkat Ali (2002), whereas, Wani *et al.* (2007) reported that backyard birds scored least Haugh Unit compared to intensive fed birds. Albumin index for scavenging birds (0.092) was comparable to that of vanaraja bird eggs as reported by Wani *et al.* (2007).

The yolk index values observed in the study were 0.353 (*ad lib*) 0.353 and 0.344 for 20 and 40% supplementation of *ad lib*. and 0.348 with scavenging at farmer backyard, which were not significantly different from each other. However, Mahbubur Rashid *et al*. (2004) observed reverse trend with significantly lower yolk index (0.441) value in scavenging conditions than other groups (0.457 -0.458). Wani *et al*. (2007) also observed that lower yolk index in scavenging (0.42) than (0.46) intensive system in Vanaraja birds. The yolk colour was superior in scavenging system of rearing when compared to all other systems of rearing which may be attributed to maximum availability of herbage or vegetation in their diets. The least yolk colour in intensive rearing may also anticipated as the only source of pigment in this group was maize. Similarly, Mahbubur Rashid *et al.* (2004) and Shawkat Ali (2002) found that the yolk colour was significantly superior for scavenging birds when compared to intensive rearing or supplemental feeding. The mean shank length were not significantly ($P>0.05$) influenced by the treatment groups (Table 2). The values ranged between 7.95 and 8.03 cm. However, as the age advanced there was an increase in the shank length. Shank pigmentation was significantly ($P<0.05$) different for all the treatment groups and as expected scavenging system gave better shank colour because of approach to greens/herbs/sherbs compared to others.

Table 1. Growth and Egg quality parameters of Rajasri birds

	7-20 weeks						40 weeks of age				
TRT	**Weight**	**FCR**	**AFE (days)**	**Age at 50% EP (days)**	**HDEP (%)**	**Liveability (%)**	**Egg Weight (g)**	**Haugh Unit score**	**Albumin Index**	**Yolk index**	**Yolk colour**
T_1	1085.62^{a}	6.38^{c}	146.50^{a}	165.75^{a}	56.83^{a}	93.75	52.60^{a}	83^{c}	0.083^{d}	0.353	3.59^{d}
T_2	653.69^{c}	3.32^{a}	188.00^{d}	214.50^{c}	22.10^{d}	87.50	50.31^{c}	86^{b}	0.084^{cd}	0.353	5.99^{c}
T_3	813.79^{b}	4.28^{b}	184.50^{c}	211.50^{c}	29.23^{c}	90.00	51.14^{b}	83^{c}	0.085^{bc}	0.344	7.84^{b}
T_4	627.63^{d}	-	171.50^{b}	191.00^{b}	37.81^{b}	85.00	49.69^{d}	89^{a}	0.092^{a}	0.348	9.61^{a}
SEM	44.15	0.53	2.79	3.57	2.415	1.093	0.256	0.214	0.0011	0.0013	0.424
P-value	0.003	0.002	0.004	0.002	0.001	0.235	0.001	0.002	0.001	0.248	0.004

Values bearing different superscripts in a column differ significantly (P<0.005)

Table 2. Shank length (cm) and Shank pigmentation from 8 to 60 weeks of age for different treatment groups of Rajasri birds

	Shank length (cm) (Age in weeks)					Shank pigmentation (Age in weeks)				
TRT	**8**	**12**	**16**	**20**	**60**	**8**	**12**	**16**	**20**	**60**
T_1	3.40	5.80	7.50	8.13	8.18	2.18^{b}	2.63^{c}	2.38^{c}	2.10^{c}	1.10^{c}
T_2	3.18	5.68	7.38	7.95	8.05	4.30^{a}	3.83^{b}	3.50^{b}	3.73^{ab}	2.10^{b}
T_3	3.30	5.78	7.18	8.05	8.11	4.43^{a}	4.53^{ab}	3.58^{b}	3.38^{bc}	2.13^{b}
T_4	3.31	5.83	7.23	8.03	8.24	4.45^{a}	5.13^{a}	4.73^{a}	4.88^{a}	4.50^{a}
SEM	0.03	0.02	0.04	0.04	0.04	0.22	0.24	0.22	0.27	0.26
P –Value	0.240	0.910	0.08	0.364	0.364	0.001	0.001	0.004	0.008	0.001

Values bearing different superscripts in a column differ significantly (P<0.005).

CONCLUSION

From this study it can be concluded that significantly better weight gain, age at first egg, age at 50% egg production, hen day egg production and egg weight was observed in intensive system group compared to others. Eggs produced from scavenging group had better quality in terms of Haugh unit, Albumin index and yolk colour compared to other groups and increased yolk colour score definitely improved the form appeal to the consumers. Significantly better shank colour was observed in scavenging group.

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PSYCHOLOGICAL ATTRIBUTES AND DEMOGRAPHIC PROFILE OF UG STUDENTS WITH ICT APPLICATION: A COMPARATIVE STUDY BETWEEN AGRICULTURE UNIVERSITIES OF TANZANIA AND INDIA

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ABSTRACT

This study was designed to assess the psychological attributes and demographic profile of UG students between Sokoine Agriculture University of Tanzania (SUA) and India (PJTSAU) and to find out the significance of difference in psychological attribute and demographic profile of the students of both universities. Exploratory research design was adopted to conduct the study whereby 200 UG students from two colleges participated in the study. Data was analyzed using different statistical techniques which included descriptive statistics, mainly mean and standard deviation and paired sample t-test. It was hypothesized that there will be no significant difference between students of PJTSAU and SUA in psychological attributes and demographic profile of UG students .Overall, the demographic profile of the students of PJTSAU and SUA differed in certain aspects, but showed somewhat uniform trend too. Paired sample t-test revealed a significant difference on demographic profile of UG students of SUA (M= 26.32, SD=2.9) compared to PJTSAU (M= 25.20, SD=2.4); t (99) = 3.24, p < 0.01. In psychological profile the PJTSAU students (M= 8.92, SD=3.6) were above than (M= 6.87, SD=3.1); t (99) = 3.56, p < 0.04 SUA. Hence null hypothesis was rejected and empirical was accepted, as there is significant difference between students of PJTSAU and SUA in psychological attributes and demographic profile.

INTRODUCTION

Present education system aims at providing the teacher and the learner to be literate of Information and communication technology and hence technology based education is the need of the hour. Exposure to the use of ICTs in the teaching and learning process makes the teacher and the student to learn things effectively. ICT now permeates the education environments and underpins the very success of 21st century education. It also adds value to the process of learning and to the organization and management of learning institutions.

ICTs by their very nature are tools that encourage and support independent learning. Students using ICTs for learning purposes become immersed in the process of learning and as more and more students use computers as information sources and cognitive tools. Use of ICT in learning settings can also act to support various aspects of knowledge construction. The continued use and development of ICTs within education will have a strong impact on: What is learned; how it is learned; when and where learning takes place; who is learning and who is teaching. However, if appropriate conditions are provided, ICT offers many solutions to solve current education problems. For example, by means of these technologies, learning and information resources have remarkably increased and got varied, therefore, it has got easier to access to these resources.

Demographic information is an essential part of any social research. Characteristics such as race, ethnicity, gender, age, education, profession, occupation, income level and marital status and on the other hand psychological attributes such as interests, hobbies, self confidence, achievement, motivation and career orientation have an impact on how a student uses ICTs in terms of availability and accessibility in enhancing the learning process.

Cakir, O (2012) carried a survey to assess the attitude of students towards the ICT and the self-confidence as the factors influencing positive or negative usage of technology. In this research, the students' self-confidence and attitudes connected with computer as a component of ICT used were analyzed. The Q8

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item of Student Questionnaire connected with computer using with self-confidence and Q10 item is connected with the attitude toward computer. It was tested whether it was different with the computer availability and gender factor with the reference to the students' self confidence and attitude. The findings revealed that gender factor is effective on both students' attitude and self - confidence. It was determined that computer availability at school and home were separately effective.

Adeyinka (2009) examines the attitudinal correlates of some selected Nigerian librarians towards the use and application of ICT in various libraries. A total of 41 librarians from automated libraries in the Oyo state of Nigeria formed the study population. The survey instrument used for the collection of data was computer anxiety and attitude towards microcomputer utilization (CAATMU) scale and a librarian attitude questionnaire. The main objective of the study was to find relationship between demographic variables of respondents, age, gender, prior knowledge / experience and training, educational qualification, computer anxiety and librarians attitude towards ICT. The analysis of results show that all the four out of the five variables age, gender, educational qualifications and knowledge of ICT significantly correlate with librarian attitude towards ICT; while the variable ICT anxiety correlate negatively with the attitude of librarian towards ICT. The study emphasizes the need for libraries to embark on training their librarian who does not have knowledge of ICT.

OBJECTIVES

1. To study the profile of UG students and teachers of College of Home Science, Professor Jayashankar Telangana State Agricultural University (PJTSAU), Hyderabad, India and Department of Food Science & Technology, Sokoine University of Agriculture (SUA), Tanzania.
2. To find out the significance of difference in demographic profile of the students of PJTSAU and SUA
3. To find out the significance of difference in psychological profile of the students of PJTSAU and SUA

METHODOLOGY

Exploratory research design was adopted to conduct the study. The study carried duly following the norms of the stratified sampling technique, equal number of students from each study year i.e. four years, were chosen from College of Home Science, PJTSAU, India, as the duration of UG programme is four years. Hence a total of 100 students @ 25 students from each year of study of all the four years of study had become the sample of the study. Similarly, a total of 100 students from Department of Food Science, Nutrition and Consumer studies, SUA, Tanzania were selected. Thus, the total size of the sample of the study was 200 UG students.

RESULTS AND DISCUSSION

In the present study the demographic profile of students included were age, gender, marital status, type of family, family income and family occupation as variables together with interests, hobbies, self confidence, achievement motivation and career orientation as psychological attributes. The data collected along these aspects from both the universities was subjected to computation and results are presented in proceeding tables.

Table 1. Distribution of UG students based on age profile

N1 =100, N2=100

Categories	PJTSAU		SUA	
	Frequency	Percentage	Frequency	Percentage
18 -20	39	39	0	0
20- 22	60	60	29	29
22- 24	1	1	54	54
24- 26	0	0	11	11
Above 26	0	0	6	6
Total	100	100	100	100
Mean	20.33		23.13	

N1: PJTSAU N2: SUA

Majority of UG students (60%) of PJTSAU were between 20-22 years of age, while in SUA were between 22-24 years (54%). Stratified sampling technique was used for sample selection and equal number of undergraduate students from each study year i.e., four years was chosen for the study. As part of the sample was from first year of study the range of age started from 18 years onwards in PJTSAU, where as it was 20 years in SUA. The mean age was 20.33 and 22.13 in PJTSAU and SUA respectively.

Family Income of the UG students

Family income was operationalized as household income which measures the combined incomes of all people sharing a particular household or place of residence. Mangal *et. al.,* (2014) updated the scale to measure socioeconomic status of the individual, for both rural and urban areas. Therefore, as per their recommendation the indices would probably give a more accurate picture of socioeconomic status classification for the entire urban and rural population and for the country as a whole. Hence was adopted for this study as well.

Table 2. Distribution of UG students based on family income

N1= 100, N2=100

Income strata	Income level/ month (Rs.)	PJTSAU	SUA
Upper Class	> 53570	-	-
Upper middle class	26520 –53560	22	12
Middle class	15700-26510	45	62
Lower middle class	8120-15700	33	26
Total		100	100

N1: PJTSAU N2: SUA

As per Indian standards of income categorization, none of the respondents were in upper class, while majority belong to middle class followed by upper middle and lower middle in both the universities. Majority of students belong to middle income class in Tanzania and India.

As per the Poverty and Human Development Report (2009), a lot of wealth was created over the past decade in Tanzania. The $480 figure is a 92% increase from 2000, when wealth per capita was at $250. Over the same period, the number of Tanzanians with assets worth $1 million or more has more than doubled, from 1,000 people to 2,200 as of 2014. The number of people able to meet basic consumption needs has risen by just over 6% since 2007, while the number of people living in extreme poverty, struggling to meet basic food needs, fell by 2% . The data of the present study is more or less on par with these findings, with high middle income families compared to India.

Family education of the students

Family education was operationalized as the level of education that the parents have acquired during the course of study whether full time or part time with recognizable certificates from the particular course i.e. degree or diploma certificates. Mothers' and fathers' educational status were studied separately. The following table 3 presents fathers' and mothers' education status.

Table 3. Distribution of UG students based on parent's education

N1= 95, N2=100, N3= 100, N4=91

Category	PJTSAU		SUA	
	Fathers	Mothers	Fathers	Mothers
Illiterate	0	0	6	2
Primary	4	11	11	21
Secondary	12	29	7	20
Higher secondary	30	30	37	13
Graduation	25	13	18	35
Post Graduation	24	17	21	0
Total	95	100	100	91

N1= Fathers' PJTSAU, N2= Mothers' PJTSAU,
N3 =Fathers' SUA, N4 = Mothers' SUA

In table 3, the trend of education among parents of the UG students of both the countries is evident. In India, no illiteracy was observed among the parents of students, where as in Tanzania it existed up to 6 percent among fathers' and 2 percent among mothers'. In India both fathers and mothers were equal

at higher secondary level (30%) while majority of fathers have graduation and post graduation degrees, while mothers' have primary and secondary level & post graduation education. In case of Tanzania, fathers' with higher secondary (37%) are more in number followed by post graduation (21%) and graduation (18%) respectively. Majority of mothers are graduates (35%) followed by primary and secondary levels. Fefferman (2012) reported that among Tanzanians aged 15 to 24 years, 79 percent of males and 76 percent females are literates according to World Bank Report. The present findings are also on par with the World Bank's report (2012).

According to Educational status at a glance (2016) the adult literacy rate in India is showing an upward trend for females as well as males. It has increased from 61% to 69.3% during the period 2001-2011. As per NSS 71st round findings, India adult literacy rate stands at 70.5% for year 2014. The present results provided an evidence of continuation of upward adult education trend.

Family occupation profile of UG students

Family occupation was operationalized as parental occupation of the respondent. Information was collected on four categories viz., Government employee, private employee, self-employment, farming and caste occupation for both mother and father. The data is presented in table 4.

Table 4. Distribution of UG students based on family occupation profile

N1= 95, N2=100, N3= 100, N4=91

Category	PJTSAU		SUA	
	Fathers	Mothers	Fathers	Mothers
Employed-Public	22	3	21	3
Employed-Private	11	20	13	32
Self employment	26	22	27	29
Farming	36	52	36	27
Caste occupation	2	5	3	0
Total	**95**	**100**	**100**	**91**

N1= Fathers, PJTSAU, N2= Mothers, PJTSAU, N3= Fathers, SUA, N4= Mothers, SUA

Data shows farming as major occupation of the mothers', and fathers' in both the study areas to a greater extent. Similar trend in case of government employment was observed in both the countries with majority of fathers being govt. employees. However mothers' were observed to be more in private employment sector than fathers, where as uniformity existed with regard to self employment. Caste based occupations were almost negligible. It can be inferred from the data, that caste occupations are decreasing, women employment is increasing and farming continues to be an important occupation.

Overall, the demographic profile of the students of PJTSAU and SUA differed in certain aspects, but showed somewhat uniform trend too. Hence paired t test was computed to statistically infer the difference.

Testing of hypothesis-1

Null hypothesis

There will not be any significant difference between students of PJTSAU and SUA in demographic profile.

Empirical hypothesis

There will be significant difference between students of PJTSAU and SUA in demographic profile

Table 5. Significance of difference in demographic profile

Mean scores		t-value	t- critical
PJTSAU	SUA		
26.32	25.2	3.24*	1.984

Significant at 0.05% level of probability

The *'t'* value was found positively significant at 0.05% level of probability. Hence, the empirical hypothesis was accepted, rejecting the null hypothesis. This means that the difference is because of the typical attributes of the sample selected for the study.

Psychological profile of UG students

Interests, hobbies, self confidence, achievement motivation and career orientation of the students were studied to infer the psychological profile.

Interests of UG students

It was operationalised as the respondent's sense of concern with curiosity about someone or something. A list of interests was provided to the

respondents to choose as many items as they are interested in. It was found that students had more than one interest. Hence, the data was computed and presented in table 6.

Table 6. Distribution of UG students based on their interests

N1 =100, N2=100

S.No	Interests	PJTSAU		SUA	
		Frequency	Meanscore	Frequency	Meanscore
1.	Learning music	78	0.78	80	0.80
2.	Travelling and exploring new places	65	0.65	72	0.72
3.	Swimming	72	0.72	68	0.68
4.	Writing diary	51	0.51	62	0.62
5.	Watching movies/cartoons	100	1.00	92	0.92
6.	Learning magic	61	0.61	81	0.81
7.	Reading	72	0.72	76	0.76
8.	Sports	76	0.76	82	0.82
9.	Knitting/sewing	68	0.68	72	0.72
10.	Writing poems	11	0.11	8	0.08
	Weighted mean score	**654**	**6.54**	**693**	**6.93**

N1: PJTSAU N2: SUA

The varied levels of interest of students were evident from the data. Watching movies was the interest for majority of students, while writing poems was for a minority.

Hobbies : A hobby is a regular activity that is done for enjoyment, during one's leisure time. Hobbies were operationalised as the respondent's activity for pleasure. Table 7 represents the sum of the attribute that the individual has.

Table 7. Distribution of UG students based on their hobbies

N1 =100, N2=100

S.No	Interests	PJTSAU		SUA	
		Frequency	Meanscore	Frequency	Meanscore
1.	Singing	12	0.12	21	0.21
2.	Reading	34	0.34	17	0.17
3.	Photography	17	0.17	16	0.16
4.	Watching TV	76	0.76	45	0.45
5.	Dancing	22	0.22	18	0.18
6.	Painting	13	0.13	30	0.3
7.	Cooking	36	0.36	51	0.51
8.	Gossiping	3	0.03	2	0.02
9.	Playing sports	39	0.39	41	0.41
10.	Net surfing	73	0.73	41	0.41
	Weighted mean score	**325**	**3.25**	**282**	**2.82**

N1: PJTSAU N2: SUA

Like interests, the students had different hobbies. Watching T.V., net surfing, playing sports, cooking and reading were some prominent hobbies of students of PJTSAU. In case of SUA cooking, watching T.V., playing sports and net surfing were found as prominent hobbies.

Self confidence of students

It was operationalised as the respondent's good feeling about oneself and capabilities. It was measured by adopting the scale developed by Keith, C (2009) with suitable modifications. The mean score obtained on each item by the students was depicted in table 8.

Table 8. Distribution of UG students based on level of Self confidence

N1 =100, N2=100

S.No.	Students	Low	Medium	High	Mean	S.D
1.	PJTSAU	10(10)	70(70)	20(20)	47.6	11.4
2.	SUA	20(20)	60(60)	20(20)	33.5	6.6

Figures in parenthesis are percentages N1: PJTSAU N2: SUA

The table above showed that the range of self confidence of the students is between 48– 34. Confidence is a measure of one's belief in one's own abilities and is considered as a psychological trait that is related to, but distinct from, both personality and ability traits. A confident person has a positive frame of mind and is likely to make the best use of his/her talents and skills in achieving positive outcomes. According to Shoemaker (2010) studied the psychological constructs of "confidence" and "self-efficacy" to evaluate the effectiveness of targeted learning objectives on student achievement. Researchers found that assessment results compared with the students' academic performance showed that change in confidence was an indication of student learning.

The table above indicated that the majority of the students in both universities were on the medium level of self confidence. Twenty percent (20%) of all students in PJTSAU and SUA were highly confident, on the other hand seventy percent (70%) and Sixty percent (60%) were moderately confident of themselves. The reason for this moderate level of self confidence among students may be an indication of inadequate resources to take up independent challenge to show their own abilities and talents.

Achievement motivation of UG students

Achievement motivation was operationalised as the respondents' need to succeed and to perform well in relation to standards of excellence. It was measured by a scale developed by Norton (2006), which contained 10 items. Agreement of the respondents to the statements as true or false was rated as 2 and 1 respectively.

Table 9. Distribution of UG students based on level of achievement motivation

N1 =100, N2=100

S.No.	Students	Low	Medium	High	Mean	S.D
1.	PJTSAU	10(10)	70(70)	20(20)	71.5	10.72
2.	SUA	20(20)	70(70)	10(10)	71.7	18.64

Figures in parenthesis are percentages N1: PJTSAU N2: SUA

The table 9. depicts the achievement motivation level of the PJTSAU students and SUA. Results revealed that majority of the students from both universities (70%) were having moderate motivation for achievement. Ten percent (10%) in PJTSAU and twenty percent (20 %) in SUA were in low level of achievement motivation. However, there were also students with high level of achievement motivation from both the universities i.e., 20 percent and 10 percent from PJTSAU and SUA respectively.

From the above results it is obvious that majority of the students were having medium level of achievement motivation. The reason for this moderate achievement motivation could be inferred as only moderate category of students may be ambitious for achieving their goals in life.

Career orientation of students

It was operationalised as the understanding of the respondent of the educational and career opportunities/profession and options which help him/her to make meaningful and informed career around them. The inventory developed by Schein (1990), was used with modification to suite the career orientation in students. The respondents need to indicate how true each item is for them as never true, occasionally true, sometimes true, often true and always true as 1, 2, 3, 4, and 5 respectively. The maximum score one can obtain was 50 and minimum 10 for each individual.

Table 10. Distribution of UG students based on level of career orientation

N1 =100, N2=100

S.No.	Students	Low	Medium	High	Mean	S.D
1.	PJTSAU	10(10)	60(60)	30(30)	82.7	3.02
2.	SUA	10(10)	60(60)	30(30)	82.4	2.76

Figures in parenthesis are percentages N1: PJTSAU N2: SUA

This shows that majority of students are having medium level of understanding on career opportunities/ profession and options around them. The observation could clearly explain that factors such as interest in the field, academic ability, familiarity, economic stability, and influential people can play role on the career decision behavior of students.

In a research study the factor "match with interest" rated over job characteristics, major attributes, and psychological and social benefits in importance when students choose a major carrier (Beggs *et al.*, 2008). Students will seek out schools that are well known for that major trade. Most students today are more concerned with the amount of money they can earn. However, there are a few students who pursue their dreams (Mcglynn, 2007).

The research findings revealed that, the students had differed on their psychological variables. This difference was subjected for computation of significance. The results obtained were presented in table 11.

Testing of hypothesis-2

Null hypothesis

There will not be any significant difference between students of PJTSAU and SUA in psychological profile.

Empirical hypothesis

There will be significant difference between students of PJTSAU and SUA in psychological profile.

Mean scores		t-value	t- critical
PJTSAU	SUA		
8.92	6.87	3.56*	1.98

Significant at 0.05 level of probability

The '*t*' value was found to be positively significant at 0.05% level of probability. Hence null hypothesis was rejected and empirical was accepted. In psychological profile the PJTSAU students were above than SUA.

CONCLUSION

The age, gender, type of family, family income, education of parents and family occupation of the students were studied as part of demographic profile. They did not have association with the ICT application of UG students. With the entry of ICT in education, at time it has become compulsory to the students to apply ICT either in the form of courses or submission of assignments or library reference work, irrespective of their like or dislike. Because of this, the demographic variables and ICT application might have no significant association.

The interests, hobbies, self confidence, achievement motivation and career orientation were the variables of psychological profile of the students. These variables also exhibited non-significant relation with ICT application in both universities. While selecting the sample, students from all the years of study i.e. first to fourth year were included. Some sample, which was in first and second year, might not yet be able to express their personal attributes and this would have influenced the scoring of the variables. Hence, it might have impacted the measurement of association. However, this issue may further be explored.

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Research Note
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EFFECT OF IRRIGATION SCHEDULING AT PHENOLOGICAL STAGES ON SEED YIELD AND WATER PRODUCTIVITY OF SAFFLOWER (*Carthamus tinctorius* L.)

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Safflower (*Carthamus tinctorius* L.) is one of humanity's oldest crops cultivated in India mainly for oil, because of its richness in the unsaturated fatty acid i.e., linoleic acid (78%) from the seeds and a reddish dye from the flowers and is cultivated on a wide range of soils ranging from light soils to heavy soils under irrigated and rainfed conditions. India is the largest producer of safflower (1.13 lakh tonnes) in the world with highest acreage (1.4 lakh ha) but with an average productivity of only 638 kg ha^{-1}. In Telangana, also it is grown in 7870 ha with productivity of 708 kg ha^{-1} (DoES, 2016). Poor crop management under input-starved conditions is the most important reason for such low productivity. Irregular rains and inadequate irrigations for safflower crop is affecting seed yield in potential areas. Under irrigated conditions, safflower can give almost double the yield of rainfed crop. Under scanty soil moisture conditions in dry lands, yield can be boosted by 40 to 60 % by providing one life saving irrigation (5 to 8 cm) at critical phases of crop growth (early stem elongation or flowering) or before soil moisture becomes limiting for crop growth (Hegde, 2002). Higher productivity can be achieved by scheduling irrigation at critical stages (Suryavanshi *et al.*, 2007) and scheduling irrigation three times to safflower crop, increased plant growth and yield parameters resulting in higher seed yields (Chordia and Paur, 1986). The information on Irrigation scheduling based on critical stages under limited water availability in Telangana is very meager. Farmers give irrigation to save the crop and improve yields. Hence, the experiment was conducted to identify critical stages of safflower for irrigation under limited water resources to make its cultivation profitable especially in Southern Telangana Zone where safflower is grown under residual soil moisture.

The study was carried out at the experimental farm of WALAMTARI (Water and Land Management Training and Research Institute) during *rabi* 2014-15, with nine treatments comprising of irrigation scheduling at different phenological stages of crop growth of safflower with one to four irrigations scheduled at early stem elongation (30 days after sowing, DAS), branching (50DAS), flowering (70DAS) and seed filling (100DAS) stages as per treatments detailed in Table 1 in randomized block design with three replications. The field capacity and permanent wilting point of soil was 23.6 and 11.8 per cent, respectively with bulk density of 1.18 g $cm^{-3}$and available soil moisture was 104.2 mm in 60 cm depth of soil. The variety, Manjeera was planted during October with a spacing of 45 cm in between the rows and 20 cm in between the plants. The soil was sandy clay loam in texture and slightly alkaline with P^H of 8.53 having low nitrogen, medium phosphorus and high potassium content and medium in organic carbon. The recommended dose of phosphorus (40 kg ha^{-1}) was applied through single super phosphate in the last ploughing and nitrogen and potassium (40 and 30 kg ha^{-1}, respectively) through urea and muriate of potash fertilizers, respectively were applied after sowing of seed followed by irrigation by check basin method. Measured quantity of water through water meter was applied as per treatments with the formula of Area x depth = discharge x time. The moisture status of soil before irrigation at different stages varied from 17.9 per cent to 12.0 per cent from 30 DAS to 100 DAS at different irrigations. A total rainfall of 15.4 mm was received in one rainy day. The crop was grown as per recommended package of practices except irrigation and need based plant protection measures were adopted. The data was analyzed statically as per standard procedure.

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The results of the experiment indicated that, seed yield of safflower was significantly influenced by scheduling irrigation at phenological stages and grain yield (3087 kg ha^{-1}) realized with irrigation at all phenological stages of crop (early stem elongation, branching, flowering and seed filling) was significantly higher than rest of the treatments (Table 1.). Next to that the yield (2976 kg ha^{-1}) obtained with three irrigations at early stem elongation, branching and seed filling (T_2) and was on par with irrigation thrice at early stem elongation, flowering and seed filling (T_3) and irrigation twice at early stem elongation and flowering (T_4) which was significantly higher than the rest of the treatments though it was significantly lower than four irrigations. This might be due to maintaining adequate soil moisture at phenological stages of crop which facilitated in better uptake of water and nutrients, having beneficial effect on growth viz., plant height, branches there by favored higher leaf area index and more production and translocation of photosynthates to the sink contributed for high dry matter production and yield attributes viz., number of seed $plant^{-1}$, number of seeds $head^{-1}$ and test weight which resulted in higher grain yield (Suryavamshi *et al.,*2007). The increase in yield was to the extent of 59.4 per cent with four irrigations at early stem elongation, branching, flowering and seed filling (T_1) compared to one irrigation at flowering stage (T_9) where as the yield obtained by only one irrigation at branching (T_8) was higher by 3.40 per cent compared to one irrigation at flowering. Similarly, two irrigations at branching and flowering (T_6) was higher compared with irrigation at branching and seed filling (T_7) and irrigation at early stem elongation and seed filling (T_5) by 22.2 and 5.9 per cent respectively and was lower by 2.5 per cent than irrigation at early stem elongation, branching and flowering (T_4) which indicates when two irrigations are available for higher yield, irrigations are to be scheduled at early stem elongation. Yield was reduced up to 2.1 per cent with irrigations at early stem elongation, flowering and seed filling (T_3) compared with irrigation at early stem elongation, branching, and seed filling (T_2) as there was no significant difference between these treatments which indicated that irrigation at seed filling was not much advantageous as these two treatments were on par with two irrigations at early stem elongation and flowering. It might be due to moisture fluctuation from field capacity to permanent wilting point in T_9 (at flowering) while in T_1 (early stem elongation, branching, flowering and seed filling) moisture was maintained near to field capacity level at different phenological stages of crop.

Significantly lower grain yield (1936 kg ha^{-1}) was observed with one irrigation at flowering (T_9) over the rest of treatments except irrigation once at branching. Similar results of higher yield with three irrigations and lower yield with one irrigation was reported by Suryavamshi *et al.* (2007). The higher seed yield with two irrigations was due to the availability of more nutrients for plant growth and higher yield attributes like heads $plant^{-1}$, seeds $head^{-1}$ and test weight (Singh *et al.*, 1995). Sufficient water precipitation resulted in the increase in number of flower heads $plant^{-1}$ and number of seeds $plant^{-1}$ there by increased seed yield as reported by Orange and Ali (2012).

The quantity of water applied to safflower in treatments where the irrigations were scheduled at all the four critical stages was more followed by water applied at three stages and so on. The quantity of irrigation water applied in each irrigation treatment inclusive of 48 mm pre sowing irrigation was 349.9, 268.4, 270.1, 190.2, 188.6, 209.3, 207.7, 127.8 and 129.5 mm and total water consumed including effective rainfall of 15.4 mm in one rainy day was 365.3, 283.8, 285.5, 205.6, 204.0, 224.7, 223.1, 143.2 and 144.9 mm in different treatments of four irrigations at early stem elongation, branching, flowering and seed filling to one irrigation either at branching or flowering (from T_1 to T_9), respectively as detailed in Table 1.

Water productivity (WP) of safflower is expressed in terms of the yield obtained per mm of water applied and significantly higher water productivity (14.12 kg mm^{-1}) was recorded with treatment where irrigation water was applied twice at stem elongation and flowering (T_4) and was on par with treatment where irrigation was given once at branching (T_8) with water productivity of 13.98 kg mm^{-1}. Next in the order was irrigation scheduled once at flowering (T_9) and was on par with Irrigation at early stem elongation and seed filling (T5) with water productivity of 13.36 and 13.09 kg mm^{-1}, respectively. Similar findings were reported by Ved Singh *et al.* (1995) who observed that maximum water use efficiency when safflower was irrigated twice at rosette (early stem elongation) + flowering (T_4) followed (by rosette (early stem elongation) + seed-setting stages (T5). Pawar *et al.* (1987) similarly recorded higher WUE when irrigation

was scheduled at rosette (early stem elongation) and flowering stage.

Water productivity (10.49 kg mm^{-1}) recorded with irrigation thrice at early stem elongation, branching and seed filling (T2) was on par with the irrigation twice at branching and seed filling (T7) and flowering and seed filling (T3) with water productivity of 10.38 and 10.20 kg mm^{-1}, respectively. Significantly lower water productivity (8.45 kg mm^{-1}) was observed with four irrigations scheduled at early stem elongation, branching, flowering and seed filling (T1) compared to rest of the treatments. This indicates that in treatment where more number of irrigations were given WUE was less and on the other hand WUE was higher when number of irrigations are reduced. With the increase in irrigation level, the WP decreased (Pillai *et al.*, 1990).

Based on the above results, it can be concluded that higher yields of safflower were obtained upon giving 4 irrigations followed by 2-3 irrigations for optimum yields under limited water availability. Higher water productivity was recorded with irrigation thrice at early stem elongation, branching and seed filling and was on par with the irrigation twice at branching or flowering and seed filling.

Table 1. Yield and water productivity of safflower as influenced by phenological irrigation scheduling

Treatment	Seed Yield (kg ha^{-1})	Applied Water (mm)*	Effective Rainfall (mm)	Total water (mm)	Water Productivity (kg mm^{-1})
T_1-Irrigation at early stem elongation, branching, flowering and seed filling	3087	349.9	15.4	365.3	8.45
T_2-Irrigation at early stem elongation, branching and seed filling	2976	268.4	15.4	283.8	10.49
T_3-Irrigation at early stem elongation, flowering and seed filling	2913	270.1	15.4	285.5	10.20
T_4-Irrigation at early stem elongation and flowering	2903	190.2	15.4	205.6	14.12
T_5-Irrigation at early stem elongation and seed filling	2671	188.6	15.4	204.0	13.09
T_6-Irrigation at branching and flowering	2829	209.3	15.4	224.7	12.59
T_7-Irrigation at branching and seed filling	2315	207.7	15.4	223.1	10.38
T_8-Irrigation at branching	2002	127.8	15.4	143.2	13.98
T_9-Irrigation at flowering	1936	129.5	15.4	144.9	13.36
SEm±	37				0.17
C.D (P=0.05)	110				0.50

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Research Note
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RELATIONSHIP BETWEEN BODY IMAGE PERCEPTIONS AND SELF ESTEEM AMONG TRIBAL ADOLESCENTS

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Adolescence is a period of life during which many important body changes take place that are determined by pubertal development. Adolescence is a time of great change not just markedby physical changes but also experiencing cognitive, social/ emotional and psychological changes. Physical and psychological changes can influence perceptions of satisfaction on their body image, there by influences the self-esteem and social adjustment of adolescents.

Body image is the mental picture that people have in their mind regarding size, shape and form of their body and also the feelings concerning the characteristics of their body parts.Going through puberty can amplify body image concerns. Zakin *et al.*1994 indicated that during adolescence, looks become more critical for girls than for boys.

Self-esteem is how we value ourselves; it is how we perceive our value to the world and how valuable we think we are to other. Positive self-esteem gives us the strength and flexibility to take charge of our lives and grow from our mistakes without the fear of rejection. Negative self-esteem makes a person feel unworthy, incapable, and incompetent. Many adolescent girls believed that physical appearance is a major part of their self-esteem and their body is a major sense of self. The dissatisfaction on body attributes leads to low self-esteem. Self-esteem is strongly influenced by self-perceptions. Adolescents developed self-perceptions by comparing themselves with media ideals, models and parental criticism towards their children body image also affects the self-esteem.Veena and Vivek (2015) in their study found that tribal adolescents compare themselves with others which lead for their low self-esteem.

It can, however, be powerfully influenced by cultural messages and societal standards related to appearance and attractiveness. Few studies revealed that there is a significant relationship between body aspects like general perceptions on body image, satisfaction towards physical attributes, regrets about body attributes, initiatives taken for body maintenance and selfesteem of urban adolescents (Divya and Mayuri, 2015). Whereas no significant relationship was found between body image perceptions and self-esteem of rural adolescents.

Much research has been done abroad and not many were done in Indian context. In fact studies on the body image perception and its relation with self-esteem of adolescents are negligible in Indian context. Even though some attempts were made in urban and rural areas but hardly there are any studies conducted in tribal area. Hence, the present study is taken up to find out the relationship between body image perceptions and self-esteem among tribal adolescents.

The study was taken up to find out the relationship between body image perceptions and self-esteem of tribal adolescents. A sample of 180 adolescents with in the age group of 11 to 13 years and 16 to 18 years was collected randomly from schools and colleges in and around Adilabad district. Body image perceptions schedule (Divya and Mayuri, 2015) and Rosenberg Self-Esteem scale (Rosenberg, 1965) were used for measuring the body image perceptions and self-esteem of the tribal adolescents. The correlation was found by using pearson correlation coefficient statistical measure.

Background of the respondents

The information about the general profile of the respondents was indicated that the sample consisted of 45 boys and 45 girls from the age group of 11-13 years and 45 boys and 45 girls from the age group of 16-18 years. A total of 90 boys and 90 girls

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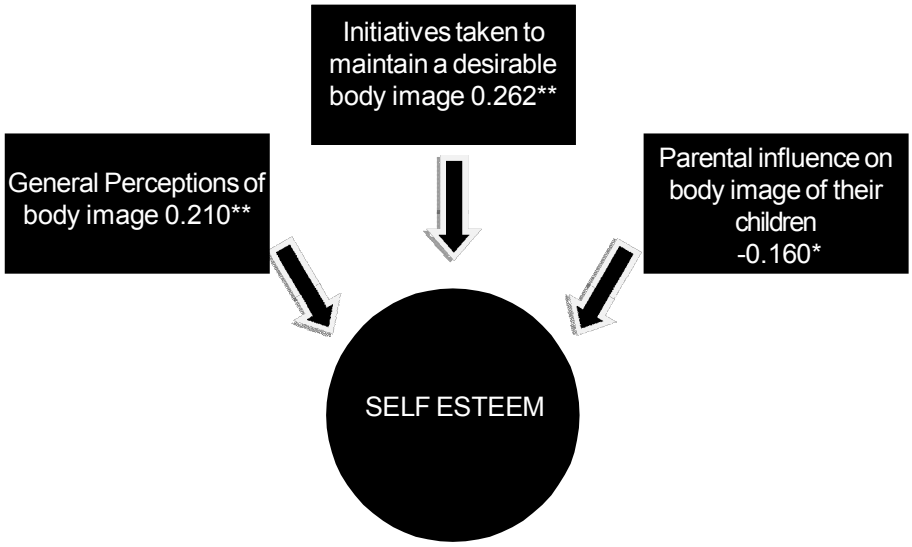
Table 1. Correlation between body image perceptions and self-esteem of tribal adolescents

S.No	Body Image Perceptions	Self Esteem
1	Perceptions of body image	0.210**
2	Extent of satisfaction towards physical attributes	0.047
3	Regrets about body image	-0.089
4	Extent of usage of cosmetics and accessories for maintaining desirable body image	-0.109
5	Initiatives taken to maintain a desirable body image	0.262**
6	Parental influence on body image of their children	-0.160*
7	Peer group influence	-0.132
8	Total body image perceptions	-0.113

P-value <*0.05 level of significance, **0.01 level of significance



The self-esteem of tribal adolescent's is correlated positively with perceptions of body image like high regards towards physical beauty and its advantages for success in life and initiatives taken such as dieting for weight loss or weight gain, exercising at home and joining gym or yoga center to maintain a desirable body image at 1% level of significance. This indicates that as perceptions on body image and initiatives taken for improvement of body image through physical fitness increases self-esteem also increases. This shows that adolescents who had high concerns towards body shape and importance of maintaining a fit body by taking some measures had positive self-image which nurtures their Self Esteem. Similarly Divya and Mayuri, (2015) found that there was a positive relation between body image perceptions and self-esteem among urban adolescents.

At the same time self-esteem was negatively correlated with parental influences on body image of their children at 5% level of significance. This means as parental influences or pressure increases self-esteem of adolescent decreases this might be due to the high comparisons, unrealistic expectations and aspirations and frequent criticism may pull down the self-esteem of adolescents.Kristen and William (2012) also found that parental negative attitudes were significantly correlated with body dissatisfaction at 1% level of significance in which low self-esteem of adolescents increases as negative attitude of parent's increases.

It was also important to note that there was no significant relationship among self-esteem and extent of satisfaction towards physical attributes, regrets about body image, usage of cosmetics and accessories and peer group influences on their body image. This might be because participation in social activities like helping others, building academic skills, talents and abilities in co-curricular activities are more important in life rather than just being beautiful or there may not be much pressure from their peers and concerned family members on desired body image or they may give more importance to functional body.

However, it was also evident from the results that there was no significant relationship between the total body image perceptions and self-esteem of tribal adolescents, which means that the self-esteem is not directly dependent upon the physical body perception of adolescents, it may depend more on their achievements, abilities and talents rather than just on aesthetic appearances of body. Similarly Shatakshi Shukla and Shalini Agarwal (2016) revealed that there was no significant relationship between total body image perceptions and self-esteem.Therefore, total body image does not affect the self-esteem of adolescents. Some aspects of body image perceptions are critical for self-esteem. Adolescents have positive perceptions towards body image and they were taking initiatives for desirable body maintenance which in turn builds their positive self-image. Hence, undue importance to body image will not be encouraged among adolescents as it hampers over all development of the adolescents. Adolescents must focus on their abilities, efforts and achievements to improve their satisfaction levels and self-confidence. Support from parents, helps the adolescents to establish a healthy body image perception and a positive self-esteem. Media has to enforce on body image ideals that are more realistic for adolescents.

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Research Note
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COGNITION ENGAGEMENT OF 8TH CLASS STUDENTS IN SCIENCE LEARNING

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Cognition engagement was endorsed by the educational psychologists as a major part of overall learning engagement. It indicates the effectiveness of the stimulus that created an environment to the learner to immerse into it. It is rather an in-depth reflective learning process that is situated in realistic problem-solving tasks. Cognition Engagement is defined as a form of instruction that challenges students to draw upon basic skills to engage in higher level thinking. According to Ge and Ifenthaler (2017) it is to engaging in effortful tasks with purposiveness and strategy use, making cognitive investment in learning, and engaging in metacognition and self-regulated learning.Chan and Bose (2016) Student's cognitive effort is invested to learn, understand, and master the intended knowledge and skills.In the present study it was operatonalised as the achievement of the learner in answering the questions of higher level thinking order.

In the present study, three lessons from Physical Science and three lessons from Biology lessons was selected to check cognition engagement of 8th class students in science learning.For this study twenty multiple choice quiz from three Physical Science lessons and three Biology lessons that required high order thinking to answer were chosen by the experts, from a total of 60 questions incorporated in six different quizzes, exclusively prepared for the current study.

Pre-test and post-test control group experimental research design, was adopted for the study. A sample of 219 students studying 8th class (169 female, 50 male students) from six Ashram high schools of Warangal district were purposively selected, as that is the end level of secondary school education, where the fundamental concept of science learning for Physical Science and Biology gets initiated. Out of which, three were girls schools located in Jaggannapet, Tadvai and Akulavari Ghanpur and three were boys schools in Raini Gudem, Kalwapally and Chinnaboina Pally, due to gender segregated admissions.

Cognition engagement was operationalised as the achievement of the learner in answering the questions of higher order of thinking. To measure this psychological variable of the sample, 20 questions that require high order thinking in answering quiz questions from Physical Science and Biology lessons, prepared for research purpose were identified with the help of experts.

The performance of the students on those questions was considered as the rate of cognition engagement. The data on this variable was computed based on pre and post Science quiz results. The maximum score of cognition engagement was 10 as each correct answer was assigned 0.5. The mean score and percent increase of cognition engagement in pre and post quiz scores were computed and tabulated.

Table 1. Percent increase of cognition engagement in Science learning

n1= 38, n2=15, n3=81, n4=10, n5=50, n6=25

S.No	School	Cognition engagement		% In crease
		Pre	Post	
1	Jaggannapet	3.09	8.09	61.8
2	Raini Gudem	2.67	7.50	64.0
3	Tadvai	3.01	8.07	62.7
4	Kalwapally	2.50	8.25	69.7
5	Akulavari Ghanpur	2.55	8.17	68.79
6	Chinnaboina Pally	2.82	8.46	66.67
	Average	**2.77 (27.70)**	**8.09 (80.90)**	**65.61**

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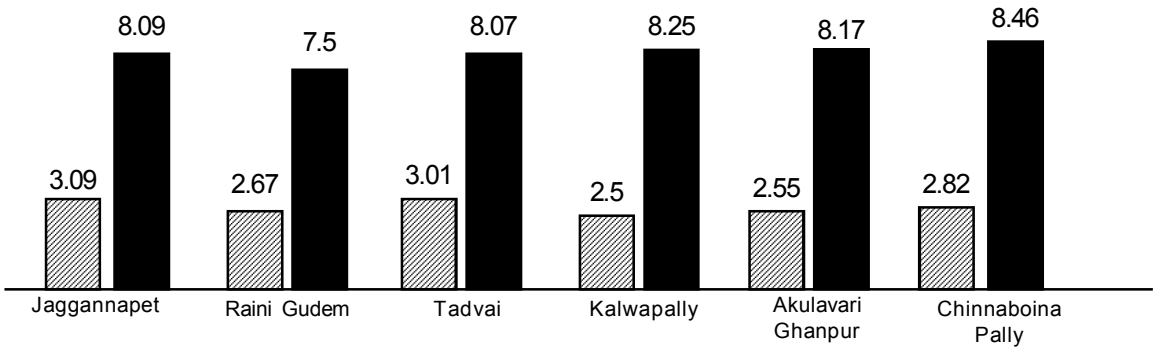
Cognition engagement in Science learning



As indicated above 27.70%was found in pre-test, in this Jaggannapet school showed highest mean score (3.09), which was girls school, followed by Tadvai (3.01), Chinnaboina Pally(2.82), Raini Gudem (2.67) , Akulavari Ghanpur (2.55) while Kalwapally school showed lowest mean score (2.50). Whereas in post-test 80.90 % was found in total six schools. Highest score was found in Chinnaboina Pally school (8.46), followed by Kalwapally (8.25), Akulavari Ghanpur (8.17), Jaggannapet (8.09), Tadvai (8.07) and lowest score was found in Raini Gudem (7.50). An increase in cognition engagement by more than 60% in post-test was found.There was increase up to 65.61% on average. But boys showed slightly more engagement (66.69%) compared to girls (64.43%).

Zhu *et al.* (2015) opined that students' learning has been the center of schooling, for which cognitive engagement is essential for achievement. When they measured the cognition engagement in physical education by analyzing the higher order questions from workbooks of students, they found empirical evidence that revealed a positive, predictive relationship between intensive writing tasks in workbooks and knowledge gain. In the present study though the relationship was not analysed, there was an increase in cognitive engagement up to 65.61% after providing the students with motivational environment through video lessons and quizzes.

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Research Note
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PERCEIVED EFFECTIVENESS AND CONSTRAINTS IN INNOVATIVE EXTENSION METHODOLOGY "MASTER TRAINERS TRAINING PROGRAMME" IN PRAKASAM DISTRICT OF ANDHRA PRADESH

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Training can be regarded as an age long concept which performs the therapeutic function of shaping knowledge, skill and attitude that are required for effective performance of duties and or assignment (Adisa and Okunade, 2005).. Using master trainers is a cost-effective way to introduce new technologies to the farmers. It is increasingly acknowledged that public extension services in developing countries are no longer able to meet the changing needs of farmers. As a result, the sector has, over the last decade, been going through a transformative process from the linear model of technology transfer to the more pluralistic demand-driven extension. These approaches focus on farmers as the principle agents of change in their communities and, therefore, enhance their learning and empowerment, thereby increasing their capacity to adapt/innovate and train other farmers. One such approach is the Master trainer approach to disseminate information/knowledge to the farmers.

Capacity building of farmers is one of the crucial mandatory activities of Krishi Vigyan Kendras. In order to enrich the knowledge, skill and attitude of the farmers in a focused way, on a selected crop, an initiative called Farmers Master Training was introduced in Acharya N G Ranga Agricultural University during 2011. It is the process wherein an identified 15-20 farmers selected from different villages spread over 2-3 mandals of a district, will be provided training at critical stages of crop selected, they will be in turn used as resource person for training other farmers of their locality. With this background Krishi Vigyan Kendra (KVK), Darsi organized three Master Trainer Trainings from the year 2011-12 to 2013-14 on bengalgram production, drum seeder paddy technology and paddy production technology. Consequently a need was felt to assess the effect of Master Trainers Training programmes organized; hence a study was undertaken with the following objectives.

1. To analyze the farmers perception on effectiveness of master trainers
2. To elicit constraints expressed by farmers in using master trainers as resource persons.

Ex-post facto research design was adopted for the study. The study was conducted in Prakasam district of Andhra Pradesh. Sixty seven master trainers have been trained from KVK, Darsi (25 farmers in Bengal gram production technology, 20 farmers in paddy drum seeder technology and 22 farmers in paddy production technology). The farmers were trained in four critical phases of the crop i.e., before commencement of the crop, at vegetative stage, reproductive phase and before harvesting covering all the recommended technologies right from seed treatment to post harvest technologies. These sixty seven master trainers were in turn used by the KVK and Department of Agriculture to train 609 farmers under various programmes. Out of 609 trainees trained by master trainers under various training programmes 150 were selected randomly, to study their perception and challenges in using master trainers for training. The data were collected with the help of a pre-tested interview schedule through personal interview.

It could be inferred from table1 that great majority of the farmers trained by master trainers felt that more number of farmers were trained by master trainers (84.00%), master trainers were able to communicate effectively (80.67%), technologies covered in trainings were feasible to adopt (74.67%), master trainers were practically involved in farming (68.67%),

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master trainers were locally available (65.33%), local language was used by the master trainers(60.67) and frequent contacts were possible with master trainers (58.00%), follow up is possible (56.67%), low cost (51.33%) and regular feedback is possible from farmers (46.00%). As master trainers were from 3 mandals they were able to train more number of farmers. Master trainers used local language to communicate recent innovations in crop cultivation which ultimately led to easy understanding by the trainees. Considering the resources available in their situation master trainers emphasized more on location specific technologies because of which respondents felt they were trained in feasible technologies for adoption. Local availability and local accent of the master trainers made them more effective with frequent contacts and easy follow up. The master trainer approach is a form of farmer-to-farmer extension where farmers take centre stage in information sharing. It is envisaged that the farmer-to-farmer extension is a more viable method of technology dissemination as it is based on the conviction that farmers can disseminate innovations better than extension agents because they have an in depth knowledge of local conditions, culture, practices and are known by other farmers. In addition, they live in the community, speak the same language, use expressions that suit their environment and instill confidence in their fellow farmers (Sinja *et al.* 2004; Lenoir, 2009). It works on the basis that the model is able to achieve economies of scale in technology dissemination by reaching more farmers more quickly. This approach has the aim of reaching a large number of farmers in communities at low cost (Noordin *et al.*, 2001).

Table 1. Perception of the farmers on effectiveness of master trainers

N=150

S.No	Perception	Frequency	Percentage
1	Increased coverage	126	84.00
2.	Locally available	98	65.33
3	Local language was used by the master trainers	91	60.67
4	Frequent contacts were possible	87	58.00
5	Effective communication	121	80.67
6	Follow up is possible	85	56.67
7	Regular feedback is possible from farmers	69	46.00
8	Low cost	77	51.33
9	Technologies trained were feasible to adopt	112	74.67
10	Master trainers were practically involved in farming	103	68.67

Information regarding constraints in using master trainers as resource persons was presented in Table 2. It could be concluded from the table that majority of the farmers felt social and caste conflicts (81.33%), sometimes master trainers were not active (54.00%), master trainers were not well equipped with the up to date information (50.67%), partiality of the master trainers in disseminating agricultural information (46.00%), master trainers were not knowledgeable (44.00%), master trainers themselves were not adopting the technologies learnt (28.00%) and no follow up (24.67%) were the major challenges in using master trainers as resource persons as perceived by the trainee farmers. Social and caste conflicts are more prevalent in the villages which ultimately adversely affecting each and every aspect of village living. Selection of master trainers is another crucial aspect which decides the efficacy of total training programme. Kundhlande *et al* (2014) reported similar difficulties in using farmer trainers. Challenges expressed by the trainees clearly emphasizes the right selection of master trainers and regular trainings to them to make them adequately knowledgeable, skillful and able to convince the farmers to adopt recent agricultural technologies.

From the results it could be concluded that majority of the farmers had positive perception on using master trainers as resource persons. Major information sources for them were neighbor farmers, dealers, department of agriculture and television.

Major challenges were social and caste conflicts, master trainers were not active sometimes and they were not equipped with up to date information. The challenges need to be addressed with continuous trainings to them to improve their knowledge and skills for best utilization of master trainers to boost agricultural production. Government and other organizations providing extension services to smallholders have limited budgets, so they are unable to hire sufficient numbers of extension agents to reach all famers who require such services. Engagement of master trainers provides the opportunity to reach more farmers at a lower cost.

Table 2. Challenges in using master trainers in training programmes as resource persons

N=150

S.No	Perception	Frequency	Percentage
1	Sometimes master trainers are not active	81	54.00
2	Social and caste conflicts in villages	122	81.33
3	Follow up was not there	37	24.67
4	Master trainers were not knowledgeable	66	44.00
5	Master trainers themselves were not adopting the technologies learnt	42	28.00
6	Partiality of the master trainers in disseminating agricultural information	69	46.00
7	Master trainers were not well equipped with the up to date information	77	50.67

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Research Note
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INFLUENCE OF AMENDMENTS OF WASTE WATER OF NOOR MOHAMMAD KUNTA ON GROWTH OF MARIGOLD (*Tagetus erecta* L.)

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Noor Mohammad Kunta, a lake located on NH-7 in Rajendranagar municipality adjoining Hyderabad city has water spread of 27 acres and an independent catchment area of 175 hectares. It flows down to Shivarampally lake then to Voora cheruvu and ultimately to Mir Alam tank. The industrial effluents of the Katedan industrial area contaminate the water of Noor Mohammad Kunta Lake at Rajendranagar. Use of such waste waters for agricultural irrigation purpose can lead to accumulation of heavy metals in the crop produce, thus entering into the food chain and thereby posing threat to human and animal health.

Marigold (*Tagetus erecta* L.), an important commercial annual flower belongs to the family Asteraceae. *Tagetus erecta* is commonly grown by the farmers on a commercial scale on account of its easy culture, wide spectrum attractive colours, shape, size and good keeping quality (Davood Hashemabadi *et al.*, 2012). In Andhra Pradesh, marigold covers an area of 6,017 ha with a production of 33, 096 metric tonnes (Indiastat, 2015). In view of these benefits to farmers, a study was taken up to understand the effect of waste waters on growth, metal uptake and yield of marigold. The experiment was laid out in Completely Randomized Block design. The treatments were replicated four times. 12 pots were maintained for each treatment. Water from Noor Mohammad Kunta was collected and diluted with normal water for analysis. Five different dilutions of water (100% normal water, 25% waste water + 75% normal water, 50% waste water + 50% normal water, 75% waste water + 25% normal water, 100% waste water) were characterized for pH, EC, TDS, Total hardness, Temporary hardness, Chemical Oxygen Demand, Dissolved Oxygen and Heavy metals (Cadmium, Chromium and Nickel). Plants were grown in pots by mixing the soil with amendments SSP @ 0.05 kg^{-1} soil + 50% dilution water, Lime @ 1.25 kg^{-1} soil + 50% dilution water, FYM @ 5g kg^{-1} soil + 50% dilution water, Rice Bran @ 2g 1^{-1} irrigation water + 50% dilution water, Hydrous Iron Oxide @ 20 mg Fe ha^{-1} + 50% dilution water.

The pots were irrigated twice a week to ensure the maintenance of adequate soil moisture. Normal tap water was used for irrigation and dilution with the waste water. Water from Noor Mohammad Kunta was collected into the clean polythene bottles. This water was mixed with normal water and used for irrigation according to the treatments. Observations were recorded on plant parameters. Soil was analyzed after crop harvest. pH of the treated water was recorded immediately after sampling, while TDS and COD were analyzed seven days after sampling. Metal accumulation in plants was analysed with AAS. SPAD Chlorophyll Meter Reading (SCMR) was computed on 2nd leaf from top with SPAD meter. SLA was calculated by the formula Leaf Area / Total plant weight.

Common practice with the farmers is to irrigate the crops with waste water and supplement irrigation with normal water as per availability. Quality of water is judged in terms of EC, SAR and Specific ion concentration. Quality of water can be grouped into good, saline and alkali water (Prasad Rao and Bhupal Raj, 2001). Alkaline nature of waste water has been reported (Barman *et al.*, 2001). pH of normal water was 8.35. Waste water substitution (25-75%) increased the pH from 9.01 to 9.11 (Table1). EC of normal water initially was 3.16 dSm^{-1}, waste water addition increased the EC to 3.28 to 4.1 dSm^{-1}. Such high pH and EC values indicated alkalinity and poor quality. Hardness of waste water along with high pH and EC has

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confounding effect on water quality (TDS, DO and COD), colour and odour. Temporary hardness was recorded in normal waters (95.18 mg 1^{-1}) and was high in treatments where waste water and its dilutions were used (112.88 to 244.58 mg 1^{-1}). Permanent hardness was also recorded in normal water (169.1 mg 1^{-1}) and in waste water (194.15 to 242.13 mg 1^{-1}).

High hardness values have been reported to be 123 to 144 mg 1^{-1} in industrial wastes and in textile industrial effluents (2140 to 3750 mgl^{-1}, Alam *et al.*, 2007). Waste water added @ 25, 50 and 75% recorded increased TDS (858.33, 889.03, and 901.95 $mg1^{-1}$ respectively) as compared to normal water (111.73 $mg1^{-1}$). Maximum TDS value was recorded in 100% waste water (937.23 mg 1^{-1}). Permissible values of DO (2.30 mg 1^{-1}) and COD (189.5 mg 1^{-1}) were recorded for normal water. COD, a measure of the ability of chemical reactions to oxidise matter in aqueous system (Swarajya Lakshmi *et al*, 2010) was also reported to be in high order in waste water (Alam *et al.*, 2007). Use of such waste water on continuous basis has been reported to build up salts, organic matter, nitrogen, other plant nutrients and heavy metals leading to soil sickness (Prasad Rao and Bhupal Raj, 2001). Farmers are forced to irrigate crops with waste water, as availability of normal water reduced,. In the present study, significantly low levels of Cd, Cr, Ni were recorded in the normal water (0, 0.002, 0.003 mg 1^{-1}) while high in waste waters (0.045, 0.059, 0.152 mg 1^{-1} respectively) as compared to USEPA standards. Waste water added at dilution of 25, 50 and 75% to normal water showed increased levels of Cd, Cr, and Ni (0.002 to 0.016, 0.032 to 0.051 and 0.050 to 0.130 mg 1^{-1} (Table 1).

Table 1. Effect of different dilutions of waste water with normal water on the water quality parameters

Treatments	pH	EC (dsm^{-1})	TDS ($mg1^{-1}$)	Total hardness (mg^{-1})	COD (mg^{-1})	DO (mg^{-1})	Cad mium (mg^{-1})	Chro mium (mg^{-1})	Nickel (mg^{-1})
100% normal water	8.35	3.16	111.73	169.10	189.50	2.30	0.000	0.002	0.003
25%waste water + 75%normal water	9.01	3.28	858.33	194.15	239.75	1.80	0.002	0.032	0.050
50% waste water + 50%normal water	9.02	3.47	889.03	254.25	289.25	1.55	0.006	0.045	0.090
75%waste water + 25%normal water	9.11	3.73	901.95	229.43	348.75	1.33	0.016	0.051	0.130
100% waste water	9.13	4.10	937.23	242.13	429.75	1.20	0.045	0.059	0.152
SE (m)	0.12	0.03	4.76	2.76	3.82	0.13	0.001	0.001	0.009
CD at5%	0.40	0.09	14.83	8.16	11.91	0.41	0.003	0.003	0.027

Metals such as Cu, Zn which are micro nutrients at low concentration become toxic at high concentration (Hodson, 2012). Metal toxicity is an important factor limiting growth of plants in many environments. Serpentine soils are very high in metals like Cr, Co, Fe, Mg and Ni but low in Ca. Low soil pH makes most metals more available for plants (Hodson, 2012). Similarly, continuous application of waste waters containing nutrients and heavy metals can also build up metal content in soils. In the present study high pH was coupled with high levels of heavy metals. The levels of heavy metals have been given in Table 1. Addition of 25 or 50% waste water along with normal water increased the Cd in soil and plant (0.015 and 0.021 mg kg^{-1} in soil; 1.86 and 1.93 mg kg^{-1} in plant). Addition of amendments like SSP @ 0.05 g kg^{-1} soil to waste water still resulted in buildup of Cd in soil and plant (0.026 and 1.37 mg kg^{-1} respectively). Other amendments like Lime, FYM and Rice bran additions to waste water decreased the Cd content in soil (0.008, 0.009 and 0.013 mg kg^{-1}) and plant (1.84, 1.72 and 1.59 mg kg^{-1}) as compared to control (normal water addition to soil (0.002 mg kg^{-1}) and in plant (0.30 mg

kg^{-1}). Cr and Ni showed similar build up in soil and plant when waste water was used as irrigation water (Table 2). Heavy metal build up over time in soil consequently resulted in an increase in plant concentrations (Cr: 1.37 to 1.93 mg kg^{-1}; Ni: 1.36 to 1.93 mg Kg^{-1}).

Table 2. Heavy metal content in the soil and plant upon the addition of waste water along with amendments.

Treatments	Heavy metal content					
	Cadmium(mg kg^{-1})		Chromium(mg kg^{-1})		Nickel(mg kg^{-1})	
	Soil	Plant	Soil	Plant	Soil	Plant
T_1 – normal water	0.002	0.30	0.080	0.30	0.210	0.30
T_2 25% waste water +75% normal water	0.026	1.93	0.170	1.93	0.930	1.93
T_3 – 50% waste water +50 normal water	0.025	1.87	0.100	1.86	1.380	1.86
T_4 – SSP @0.05g Kg^{-1} soil +50% dilution water	0.021	1.37	0.080	1.84	0.150	1.84
T_5 – lime @1.25g Kg^{-1} soil +50 % dilution water	0.008	1.84	0.160	1.37	0.360	1.36
T_6 – FYM @ 5g Kg^{-1} soil + 50% dilution water	0.009	1.72	0.080	1.72	0.330	1.71
T_7 – Rice bran @2gl^{-1} irrigation water +50% dilution water	0.013	1.59	0.180	1.59	1.380	1.61
T_8 – Hydrous iron oxide @ 20mg Fe ha^{-1} + 50% dilution water	0.011	1.42	0.190	1.42	1.420	1.43
SEm±	0.002	0.013	0.015	0.026	0.014	0.072
CD at 5%	0.005	0.038	0.044	0.077	0.004	0.212

Most plants are badly affected by high concentration of toxic metals. Sometimes non tolerant plants have evolved races that are tolerant to toxic soils called edaphic ecotypes (Hodson, 2012). Plants also develop mechanism to eliminate / tolerate heavy metals by various mechanisms. Plants breeding methods can be invoked to increase the heavy metals concentration in plants by way of producing plants with increased dry matter which accumulates the increased levels of metals. However, other strategies of prevention of metals include their preferential accumulation in roots compared to shoots as recorded in sorghum, sunflower and cauliflower (Shanker, 2005). Marigold, a flowering plant is one such hyper accumulator of heavy metals and offers choices to reduce the metal levels in soil and thereby facilitate removal from soil.

Plant growth and characters can be affected by presence of heavy metals in their vicinity. Marigold plants applied with normal water recorded maximum height (31.63 cm), while waste water applied plants showed decreased height (22.5 to 24.5 cm). On the contrary, waste water along with amendments (T4, T6) recorded height on par with normal water (34.5 and 32.25 cm). Similar observations of superior performance of marigold was indicated by high values of SCMR and SLA, the two indicators of physiological status of plants. Low SLA indicates less leaf area and suffering of plant from some type of stress (water/ nutrient/ salt/ environment). Maintenance of such low SLA is an adaptive mechanism to prevent exposure to external stress. High SCMR and low SLA was recorded in waste water amended treatments (Table 3). The better performance of crop is attributed

to increase in sorption capacity by amendments like FYM and immobilization of Cr by phosphates (Branzini and Zubillag, 2012). Adverse effects of Ni on the other hand have been reported on SCMR (Bosiacki and Wojciechowska, 2012) and flower yield reduction by Cd (Maciej Bosiacki, 2009). SSP, Lime, FYM, Rice bran and hydrous Iron oxide countered the effects of heavy metals and improved the flower number in marigold (Table 3). SSP and FYM additions increased the flower yield of plant (561.8 and 455.8 g plant^{-1} respectively) and recorded high yields on par with the use of normal water (475.6 g plant^{-1}).

Application of SSP and FYM to the soil irrigated with waste water reduced the toxic effects. Lack of availability of normal water forces the farmer to add SSP and FYM as amendments to waste water which are otherwise available in plenty which has resulted in better yield in marigold.

Table 3. Effect of different amendments to waste water on plant characters

Treatments	Plant height (cm)	SCMR	SLA ($cm^2 g^{-1}$)	Number of flowers	Flower yield (g plant $^{-1}$)
T_1 – normal water	31.63	59.68	75.46	5.0	475.6
T_2 25% waste water +75% normal water	24.50	50.78	40.31	2.3	224.4
T_3 – 50% waste water +50 normal water	22.50	43.90	41.26	3.3	217.6
T_4 – SSP @0.05g Kg^{-1} soil +50% dilution water	34.50	60.70	76.61	10.0	561.8
T_5 – lime @1.25g Kg^{-1} soil +50 % dilution water	31.75	56.18	67.31	5.5	312.7
T_6 – FYM @ 5g Kg^{-1} soil + 50% dilution water	32.25	53.93	71.46	7.0	455.8
T_7 – Rice bran @2gl^{-1} irrigation water +50% dilution water	31.00	46.48	61.66	4.8	323.3
T_8 – Hydrous iron oxide @ 20mg Fe ha^{-1} + 50% dilution water	28.13	52.83	55.35	5.0	344.5
SEm ±	0.7	1.73	2.54	2.8	14.93
CD at 5%	2.08	5.17	7.52	5.4	44.21

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GUIDELINES FOR THE PREPARATION OF MANUSCRIPT

1. Title of the article should be short, specific, phrased to identify the content and indicate the nature of study.
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3. The full length paper should have the titles ABSTRACT, MATERIAL AND METHODS, RESULTS AND DISCUSSION, REFERENCES-all typed in capitals and bold font - 12. The Research Note will have only one title REFERENCES.
4. **ABSTRACT**: The content should include the year, purpose, methodology and salient findings of the experiment in brief not exceeding 200 words. It should be so organised that the reader need not refer to the article except for details.
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