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MARKER ASSISTED BREEDING WITHOUT BACKGROUND SELECTION FOR IMPROVEMENT OF DROUGHT TOLERANCE IN A BREAD WHEAT CULTIVAR

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ABSTRACT

Drought stress is a major limiting factor in wheat production. The study was conducted during rabi crop seasons from 2010-11 to 2019-20 by utilizing a marker-assisted selection scheme to introgress a major drought insensitive yield QTL (*Qyld.csdh.7AL*) from SQ1 into Indian wheat cultivar (HD2967) using SSR marker *Xwmc273.3*, leading to the development of 3 improved wheat lines having relatively higher grain yield under water stress condition. HD2967, a high yielding wheat cultivar which has been proved as a successful variety for northwestern plain zone (NWPZ) of India but sensitive to drought stress, was used as the recurrent parent. For introgression of this major yield QTL, a cross between HD2967 and SQ1 was made and subsequently two back crosses with recurrent parent (HD2967) were attempted during the off/crop seasons. QTL was validated in the BC_1F_2 population using foreground selection followed by the collection of phenotypic data (grain weight/ear, grain weight/plant, plant biomass, flag leaf chlorophyll content, and harvest index) of two groups of plants having SQ1 and HD2967 alleles for the QTL. After foreground and phenotypic selection, homozygous superior lines containing the SQ1 allele for the QTL *Qyld.csdh.7AL* were selected in BC_2F_4 population. The high yield in the selected plants was attributed to grain weight/plant, biomass/ plant, and flag leaf chlorophyll content.

Keywords: Wheat, HD2967, MAS, QTL, foreground selection, phenotypic selection

INTRODUCTION

The hexaploid wheat (*Triticum aestivum* L.), which is often described as bread wheat or common wheat is cultivated over a wide range of climatic and soil conditions. During the last decade, a decline in the rate of annual increase in the world wheat production was witnessed. This drop in rate of increment in wheat production also led to hike in price of wheat grain in world market, thus, limiting the availability of wheat grain to the poor peoples in the developing countries. It has been realized that the above drop in the rate of annual increase is partly due to the abiotic and biotic stresses experienced by the wheat crop around the world. In India, drought is the main abiotic stress that has a

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negative impact on crop growth and yield (Sallam *et al*., 2019). Drought tolerance is the ability of plant to survive itself in limited water supply (Ashley, 1993). However, drought tolerance is a complex polygenic trait and therefore many factors come in to play making the plant drought tolerant. Drought tolerance mechanisms can be morphological, physiological or molecular (Bohnert *et al*., 1995). Morphological mechanisms include the following. (i) Drought escape, which is the ability of plant to complete its life cycle before the onset of drought season (Mitra, 2001). (ii) Drought avoidance, which is the ability of the plant to hold water by increasing the uptake of water and reducing its loss through decreased transpiration made possible by leaf and stomatal qualities as well as long and thick root network (Blum, 1988; Turner *et al*., 2001; Izanloo *et al*., 2008; Agbicodo *et al*., 2009). Among the physiological mechanisms, osmotic change is the most significant factor which permits the cell to diminish osmotic potential and maintain the turgor and the plant is able to sustain itself in diminished water supply (Blum, 2005). The role of abscisic acid (ABA), a stress hormone, in drought tolerance cannot be overlooked. Under water stress conditions, ABA induces the closure of stomata and reduce the water transpiration (Turner *et al*., 2001). Glaucousness (a waxy covering over the cuticle) is also considered to be a reliable parameter leading to increase in water use efficiency in wheat plant thus providing a mechanism of drought tolerance (Richards *et al*., 1986). The molecular mechanisms involve activation of a cascade of genes which ultimately make the plant desiccation tolerant (Agarwal *et al*., 2006; Umezawa *et al*., 2006).The elucidation of genomic regions associated with the expression of traits involved in drought adaptation, the novel gene discovery or the determination of their expression patterns in response to drought stress will provide not only the better understanding of the mechanisms for drought tolerance and also the basis of future strategies for developing wheat varieties with improved tolerance to water stress conditions. Various efforts to mitigate drought through breeding tolerant varieties are underway across the world (Mwadzingeni *et al*., 2016). During the last decades, in several countries, breeders have attempted to produce modern varieties that are highly productive and widely adapted to contrasting environments (Boussakouran *et al*., 2019).

Traditionally, breeders have depended on visual selection choice to create improved varieties which is often not effective and difficult for some complex traits. Therefore, in recent years, marker assisted selection (MAS) is being successfully used for the improvement of several traits. MAS relies on DNA based markers associated with the desired traits so that plants that carry a desirable trait can be picked up quickly by looking for the DNA markers. Molecular markers make it workable for breeders to combine favorable alleles at a larger number of loci and at early generations than is possible with conventional breeding methods. Molecular markers can also circumvent more cumbersome, established pedigree breeding strategies, and may produce plant genotypes unachievable by traditional methods (Gupta *et al*., 2010). MAS also provides a strategy for accelerating the process of wheat breeding. The grain yield under drought has low heritability and shows large genotype × environment interaction making selection for grain yield inefficient (Smith *et al*., 1990). Molecular markers associated with quantitative trait loci (QTL) for grain yield could greatly enhance progress in breeding for higher grain yield under drought. In the past, in a study involving Chinese Spring (CS) × SQ1 population, Quarrie *et al*. (2005) identified major QTL for grain yield on 7AL, expressed mainly under stressed conditions. SQ1 allele of the QTL on 7AL contributed to increased yield. Near-isogenic lines (NILs) for the 7AL yield QTL with CS or SQ1 alleles in the SQ1 background showed the SQ1 allele to be related with ~20% better yield per ear, significantly higher flag leaf chlorophyll content, and wider flag leaves (Quarrie *et al*., 2006).

The problem of drought is likely to increase in the coming decades due to anticipated climate change at the global level. Keeping this in view, a marker assisted selection (MAS) program was initiated for the development of drought-tolerant wheat genotypes. The major objectives of this study were development of high yielding plants/ lines under water stress following molecular marker-assisted introgression of the major QTL (*Qyld.csdh.7AL*) into high yielding wheat cv HD2967 and validation of QTL (*Qyld.csdh.7AL*) in HD2967 genomic background for high grain yield under water stress condition.

MATERIAL AND METHODS

Plant Materials

The genotype SQ1 that carries a major QTL (chromosome arm 7AL) for high grain yield under water stress is being used as the donor parent and HD2967 was used as recipient parent in this study. HD2967 was recommended for cultivation under timely sown and irrigated conditions in the northwestern plain zone (NWPZ). The pedigrees of both varieties were different and hence these were genetically diverse (Table 1). Plants for this study were grown in rabi crop season.

Table 1. Details of the bread wheat genotypes used in this study

Genotype Name	Characteristics
HD2967	Released in 2011 (in India); High yielding under irrigated condition
SQ1	High abscisic acid breeding line

QTL used for development of improved lines

The major drought insensitive yield QTL (*Qyld.csdh.7AL*) for grain yield located on chromosome arm 7AL and linked with SSR marker *Xwmc273.3* was used for introgression into HD2967 wheat cultivar. This major yield QTL was previouslyidentified in a mapping population of Chinese Spring (CS)/SQ1,explaining ~20% phenotypic variance (Quarrie *et al*., 2005). The SQ1 allele of this QTL is insensitive to the water stress conditions and is associated with higher yield per ear, significantly higher flag leaf chlorophyll content and biomass (Quarrie *et al*., 2006).

Marker used for foreground selection

DNA isolation and foreground selection were carried out using flanking marker *Xwmc 273.3* (forward primer:5'AGTTATGTAT TCTCTCGAGCCTG3' and reverse primer: 5'GGTAACCACTAGAGTATGTCCTT3'). The flanking marker of the target QTL (*Qyld.csdh.7AL*; Quarrie *et al*., 2006) included *Xwmc 273.3*, which was found to be closely linked with the QTL (less than 4 cM away from the QTL in the distal region of chromosome arm 7AL). The flanking SSR marker was also used in bulk segregant analysis (BSA) of segregating BC_1F_2 population. The foreground selection for drought tolerance was carried out using the above marker in all populations. The marker *Xwmc 273.3* was synthesized by *Infobio* Pvt. Ltd., Bengaluru, Karnataka, India using forward and reverse primer sequences that were available online (Source: https://wheat.pw.usda.gov/cgi-bin/GG3/browse.cgi).

Introgression of the QTL usingmarker assisted selection

Development of improved lines

The back-cross breeding scheme used to transfer the stable and major QTL (*Qyld.csdh.7AL*) for grain yield into the background of HD2967 is presented in the Fig. 1. The experimental work was conducted during rabi crop seasons from 2010-11 to 2019-20. F_1 plants generated from the cross HD2967/SQ1 were backcrossed with 'HD2967' to generate BC_1F_1 generation. After foreground selection using the SSR marker *Xwmc273.3* (linked to the QTL *Qyld.csdh.7AL*), the desirable heterozygous BC_1F_1 plants having maximum phenotypic similarity with recurrent parent were selected and backcrossed once again with 'HD2967' to develop BC_2F_1 generation.Twelve heterozygous BC_1F_1 plants were selfed to generate BC_1F_2 generation which was used for validation of QTL in HD2967 genomic background.In BC_2F_1, again marker-assisted foreground selection was carried out to select heterozygous plants having maximum phenotypic similarity with recurrent parent. Selected BC_2F_1 plants were selfed to generate BC_2F_2 generation.The BC_2F_2 and BC_2F_3 plants were subjected to foreground selection; followed by phenotypic selection to identify homozygous QTL-positive plants for drought tolerance with maximum similarity with recurrent parent. In BC_2F_4, homozygous plants/lines similar to HD2967 were selected based on morpho-physiological and yield traits under water stress.

DNA extraction, polymerase chain reaction amplification and electrophoresis

DNA isolation was carried out from the fresh leaves of about one-month old wheat seedlings using a modified CTAB method (Saghai-Maroof *et al*., 1984). The concentration of the purified DNA was determined by visual comparison with the known amount of ë- DNA on agrose gel. PCR amplification of genomic DNA was carried out using SSR marker (*Xwmc273.3)* linked to the QTL (*Qyld.csdh.7AL*; Quarrie *et al*., 2006) and showed polymorphism between HD2967 and SQ1 genotypes. Primers were synthesized using sequences that were available online (http://wheat.pw.usda.gov). For genotyping, PCR amplification was carried out in a 20µl reaction mixture containing 10-50ng template DNA, 1X PCR buffer (Tris–HCl buffer of pH 8.8), 200 µM dNTPs (Sigma), 2.5mM $MgCl_2$, 0.5 U per reaction Taq DNA polymerase (Sigma) and 2 µM of each forward and reverse primers. PCR cycle programming include an initial denaturation for 4 minutes at 94^{o}C, followed by 30 cycles each with 1 minute at 94^{o}C, 1 minute at 51^{o}C, and 2 minute at 72^{o}C with a final extension at 72^{o}C for 10 minutes.The amplified product was separated using polyacrylamide gel electrophoresis (10%

PAGE gel) and silver staining was carried out to resolve the SSR products.

Determination of morphological/ physiological traits for QTL validation

The chlorophyll content in the flag leaf was determined using a SPAD meter. Three measurements in the middle of the flag leaf were made randomly for each plant and the average sample was used for analysis. The number of spikes/plant was recorded at heading stags to avoid any ambiguity in the counting. Plant biological yield or biomass (above ground), grain yield/plant, and grain yield/spike were determined by harvesting crop at maturity.

Harvest index was calculated as grain yield fraction of total above ground biomass.

$$\text{HI (\%)} = \frac{\text{Grain yield}}{\text{Total above ground biomass}} \times 100$$

Validation of QTL

In BC_1F_1 generation, heterozygous plants were selfed and BC_1F_2 plants were used for QTL validation to check the effect of QTL (*Qyld.csdh.7AL*) in HD2967 genomic background. Plants were grown under rainfed conditions. Bulked segregant analysis (BSA) was performed for validation of QTL using SSR marker *Xwmc273.3* linked with the above QTL for grain yield and significance of difference between the two pools was tested. BC_1F_2plants were subjected to foreground selection using SSR marker *Xwmc273.3* and plants homozygous for the marker alleles belonging to SQ1and HD2967 types were grouped separately. Phenotypic data for different traits (biomass/ plant, SPAD value, seed weight/plant, spikes/ plant seed weight/spike and HI) was collected for both the groups and subjected to statistical analysis for QTL validation.

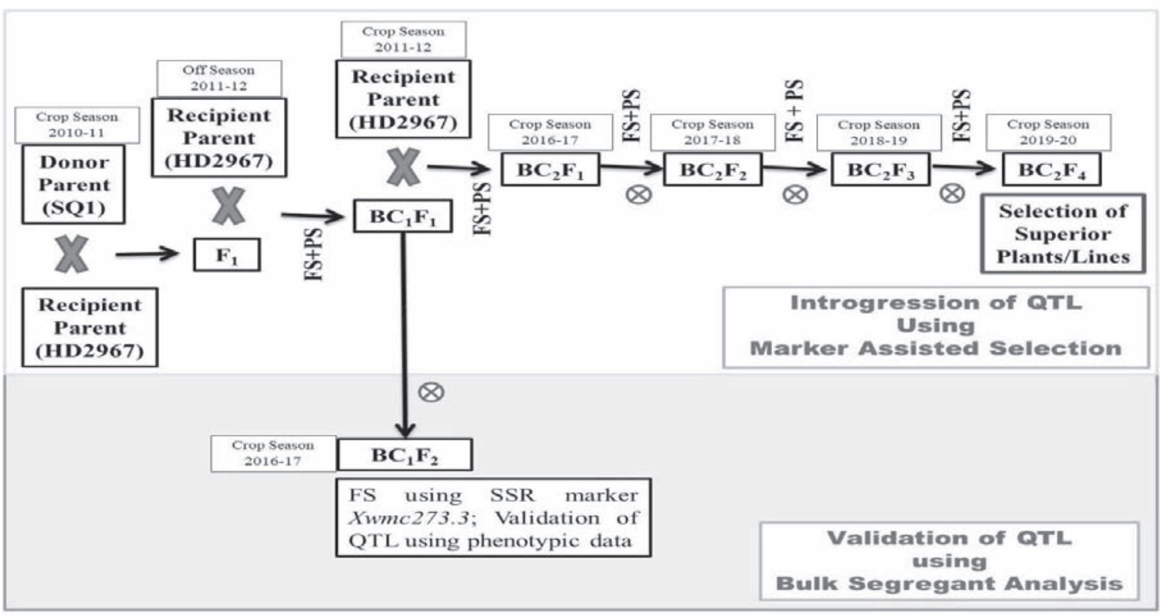

Fig. 1. An outline of molecular marker-assisted selection (MAS) scheme for introgression of QTL (*Qyls.csdh.7AL*) for grain yield under water stress. FS= Foreground Selection; PS= Phenotypic Selection; BC= Back Cross; ⊗ = Self Fertilization

Phenotypic selection of MAS-derived progeny

In BC_2F_4 generation, phenotypic selection was carried out under drought stress to select the high yielding plants lines similar to parent (HD2967). For creating drought stress, the field was irrigated only twice (one presowing irrigation and one after 21 days of sowing at crown root stage) to raise the crop. Phenotypic data for various morphological/physiological traits such as number of spikes at heading stage, chlorophyll content at grain filling stage and plant biomass and grain yield at maturity of plants, were recorded.

Statistical analysis

The descriptive statistics like mean and standard error were calculated using SPSS software version 16. t-test for validation of QTL and ANOVA for comparision of different trait values of selected plant lines with parents, were also carried out using SPSS software version 16.

RESULTS AND DISCUSSION

Marker assisted selection for development of improved lines

In the BC_1F_1 population, nearly half of the BC_1F_1 plants (100 out of 199 plants) showed an amplification pattern similar to the recipient parental genotype HD2967, and the remaining half plants showed an amplification profile similar to that of the donor parent SQ1 (Fig. 2). After that in the BC_2F_1 population, foreground selection was carried out and plants heterozygous for QTL were selfed to obtain BC_2F_2 seeds. BC_2F_2 seeds of selected plants were sown in different lines and BC_2F_2 plants containing the SQ1 allele in homozygous condition for the QTL were selected after phenotypic selection. These plants were selfed to get BC_2F_3 seeds. Seeds of 20 selected plants were sown at different lines in next cropping season and seven homozygous BC_2F_3 plant lines containing the SQ1 allele for the QTL *Qyld.csdh.7AL* were selected after foreground and phenotypic selections. In BC_2F_4 generation, selected plant lines were evaluated along with parents under water stress conditions and 3 phenotypically superior plants/lines were identified.

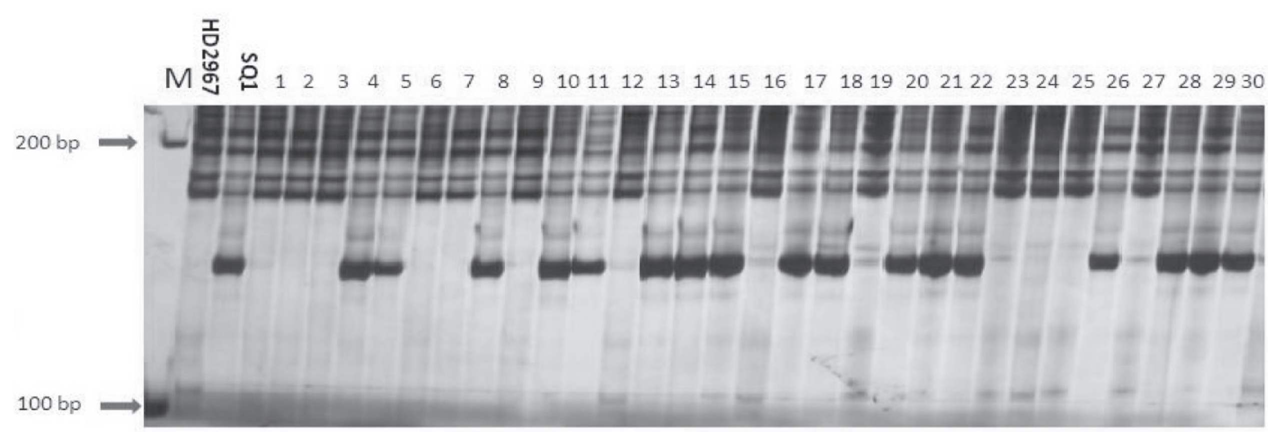

Fig.2.Representative PCR amplification profile in the two prenatal genotypes (SQ1 and HD2967) a random set of thirty (30) BC_1F_1 plants due to SSR marker *Xwmc273.3*

Table 2. Different average trait values of chosen best performer plants lines (L_1, L_2 and L_3) in BC_2F_4 population along with parents (P_1 and P_2)

Genotype	Plant Height (cm)	SPAD reading	Biomass/ Plant(g)	Spike no./ Plant	Grain Yield/ Plant(g)	Grain Yield/ Spike(g)
HD2967-79-16 -12-6-2 (L_1)	82.28^{ns}	55.89*(a')	20.68**(a, a')	9.2 ^{ns}	9.37*(a);**(a')	1.03 ^{ns}
HD2967-58-38-8-4-3(L_2)	81.60 ^{ns}	55.57 ^{ns}	19.82** (b, b')	9.4 ^{ns}	9.30** (b')	1.00 ^{ns}
HD2967-20-12-15-3-5 (L_3)	83.04 ^{ns}	54.23 ^{ns}	18.92** (c, c')	9.2 ^{ns}	9.24** (c')	1.01 ^{ns}
HD2967 (P_1)	83.00	55.37	15.10	9.2	8.23	0.90
SQ1(P_2)	85.66	53.23	12.72	8.8	6.76	0.78

*, ** = Significant at $P < 0.05$ and $P < 0.01$ respectively; ns= Non-Significant; a= P_1 vs L_1; b= P_1 vs L_2; c= P_1 vs L_3; a' = P_2 vs L_1; b' = P_2 vs L_2; c' = P_2 vs L_3

Statistics of high yielding MAS-derived plants/lines

All promising plants/lines (7 BC_2F_3plants/ lines) seeds were raised at research farm, Kisan (P.G.) College, Simbhaoli, Hapur, Uttar Pradesh, India, for evaluation of the effect of the introgressed QTL. In BC_2F_4, the selected plants/ lines were characterized for different morphological and physiological characters under drought stress and plants/lines showing improvement over recurrent parent 'HD2967' were selected.Different trait values of all the MAS-derived plants/lines for all the different traits showed variation under rainfed environments (Table 2). Almost all the trait values of some of the MAS-derived plants exceeded the mean values of their respective recipient genotypes.

QTL validation

The targeted QTL-associated SSR marker *Xwmc273.3* was validated for associations with its linked traits in the segregating BC_1F_2 generation through bulk *segregant* analysis (BSA). The distributions of the mean values for all the different traits in two groups are shown in Table 3. The mean values for all traits (except spike number/plant) were found significantly higher in BC_1F_2 plants having SQ1 type allele in HD2967 background. For spike number/plant, mean values did not differ significantly (Table 3).

The identification and introgression of QTL regions with a large and consistent effect on yield under drought present an opportunity to improve high yielding drought-susceptible mega-

Table 3. Mean trait value and standard error for BC_1F_2 population plants for QTL validation. Marker genotype 0 and 1 for BC_1F_1 plants having genotypes like SQ1 and HD2967, respectively

Marker Geno types	Traits											
	SPAD Reading		Biomass/ Plant(g)		Seed weight/ Plant(g)		Spike no./ Plant		Seed weight/ Spike(g)		HI%	
	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.
0	53.34	0.24	14.38	0.62	5.65	0.22	6.53	0.23	0.88	0.03	38.74	0.62
1	55.49**	0.27	17.09*	0.99	6.58*	0.30	6.89ns	0.27	0.96*	0.03	45.02**	2.04

*, ** = Significant at $P < 0.05$ and $P < 0.01$ respectively; ns= non-significant

varieties through MAB. In this study, QTL for grain yield under drought was associated with marker *Xwmc273.3* and explained ~20% of the phenotypic variation. Flag leaf chlorophyll content, seed weight/plant, seed weight/spike, HI and above-ground biomass were found significantly associated with the QTL.

Only foreground selection using the selected marker alongside phenotypic selection turned into almost capable of making an awesome screening of selected genotypes.In different generations plants were selected based on foreground selection using QTL linked marker and plants resembling/improved over the recurrent parents; no marker-assisted background selection was undertaken. So, each of these selected plants should carry a high proportion of the recurrent genome because plants having higher similarity with HD2967 were selected after foreground selection. Background selection is often not an essential requirement in some MAS programs for crop improvement unless the recovery of the background of the recurrent parent is a crucial requirement as done in several crops including wheat (Gautam *et al*., 2020), maize (Gupta *et al*., 2009) and rice (Chen *et al*., 2000).

The presence of QTL in improved lines was confirmed using PCR amplification of genomic DNA utilizing SSR marker (*Xwmc 273.3)* linked to the QTL. As the QTL region is thought to control a number of traits that are directly associated with yield, the QTL region may be responsible for enhanced drought tolerance response. This, however, needs to be further confirmed by more detailed studies like fine mapping of the transferred QTL region and checking for any potential recombination.

Drought tolerance is a complex trait that is controlled by several QTLs having major/minor effects. Hence, there is a need to transfer more than one QTL, as a single QTL can not lead to the desired improvement (Rai *et al*., 2018). In wheat, the yield is contributed by a number of traits like spike number, chlorophyll content, number of seeds/spike, spike length, and grain yield/plant (Mollasadeghi *et al*., 2011). Under rainfed environment, the positive significant correlation of grain yield per plant was found with contributing yield traits, chlorophyll content, yield/

ear (Bansal *et al*., 2016) and negative correlation with canopy temperature (Srivastava *et al*., 2017) indicated that morpho-physiological traits are also important to improve grain yield under drought stress. The chlorophyll content (SPAD readings) in the L_1 lines was found to be higher than the recipient parent (P_1). In L_1, grain yield/ plant and biomass/plant were higher than both parents (P_1 and P_2). The derived lines having the different phenotypic expression of the targeted traits and indicated a significant increase in chlorophyll content, biomass/plant, and grain yield/plant. Improvement in the traits associated with drought tolerance was observed in all the MAS-derived plants/lines containing the QTL. Improved lines were found to be superior to both the parents in yield.

The present QTL was transferred through the MABB program led to the development of improved lines that are tolerant to drought stress. All improved lines have desirable morpho-physiological traits and higher grain yield compared to the original parent 'HD2967'.

CONCLUSION

Utilizing marker-assisted selection, a major drought insensitive yield QTL (*Qyld.csdh.7AL*) was introgressed into Indian wheat cultivar (HD2967), leading to the development of improved plants/lines having relatively higher grain yield (up to ~14% high) under rainfed (RF) condition. Improvement in the traits associated with drought tolerance was observed in all the MAS-derived plants/lines containing the QTL.

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GENETIC ANALYSIS OF YIELD AND ITS ATTRIBUTES IN RICE (*Oryza sativa* L.)

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ABSTRACT

The experiment (2014-16) was conducted to study the genetic parameters for yield and its contributing traits revealed that number of unfilled grains/ panicle, 1000 grain weight and grain yield recorded high PCV and GCV values. High heritability with high GA as% of mean (genetic advance as percent of mean) was observed for effective bearing tillers per plant, number of filled grains/panicle, number of unfilled grains per panicle, 1000 seed weight and grain yield indicating the involvement of additive gene action in the inheritance of the traits hence it is sufficient to follow simple selection. A light on correlation studies revealed that positive direct effect of grain yield was observed with number of ear bearing tillers per plant, number of filled grains/ panicle, harvest index, days taken for 50% flowering and days taken for maturity and selection may be effective based on these traits to isolate high yielding genotypes. Path coefficient analysis revealed that, days taken for maturity, number of ear bearing tillers/plant, number of filled grains/ panicle and harvest index had shown high positive direct effect as well as positive association with grain yield. Hence, the above traits may be considered as an important criterion in the rice improvement programme

Key Words: Rice, genetic parameters, path coefficient analysis, yield

INTRODUCTION

Rice is the staple food crop of more than one third of world's population. It is a flexible crop and can be grown for a range of agro-climatic conditions. Many efforts were made by the scientists for improvement of varieties already we reached a plateau regarding yield. It is the time to break the plateau and improvement of yield to feed the ever growing population. Before launching any breeding programme, a thorough knowledge on the nature and magnitude of genetic variability present in the crop species is important to the plant breeder because greater the variability larger the scope for improvement. Heritability of a quantitative trait is a parameter of particular significance to the plant breeder as it measures the degree of resemblance between the parents and offspring and its magnitude indicates the probability with which a genotype can be identified by its phenotypic expression. Genetic advance for any quantitative character in a segregating population can be predicted with the help of heritability and aids in exerting the necessary selection pressure. Yield is a complex

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and quantitatively inherited character with low heritability, hence, it is ineffective direct selection for yield is ineffective. Therefore, with the help of character association studies, it is possible to know the characters that are associated with each other in improving the yield of a crop.

MATERIAL AND METHODS

The investigation was carried out at Agricultural Research Station, Nellore, situated in southern agro-climatic zone of Andhra Pradesh, India located at an altitude of 20M above MSL, 14021'N latitude and 79059'E longitude during 2014, 2015 and 2016 *kharif,* 2014 and 2015 *rabi* seasons with 20 hybrids (derived from crossing five lines with four testers in line × tester fashion) along with nine parents to assess the variability, heritability, genetic advance, character association, direct and indirect effects for grain yield and its component traits in rice.

The experimental trial was laid out in a (RCBD) randomized complete block design with three replications under transplanted conditions. Each plot comprised of four rows of 3.0 m length spaced 20 cm apart with plant to plant spacing of 15 cm. Replication-wise data on the basis of five randomly taken competitive plants were recorded on plant height (cm), number of effective tillers/ plant, panicle length (cm), number of filled grains/panicle, number of unfilled grains/ panicle, grain yield (g/ plant), test weight (g), SCMR(SPAD Chlorophyll meter readings) and harvest index (%), while data on days taken for 50% panicle initiation and days taken for maturity were recorded on plot basis. The statistical analysis was done according to Hanson *et al.* (1956) for Heritability estimation, Johnson *et al.* (1955) for genetic advance estimation, falconer (1964) for correlation studies and path correlation analysis were carried out as per the procedures given by Wright (1921 and Dewey and Lu (1959).

RESULTS AND DISCUSSION

In the investigation, the analysis of variance indicated significant differences for majority of the characters studied. The PCV (phenotypic coefficient of variation) was higher than the GCV (genotypic coefficient of variation) indicating the influence of environment in the expression of the traits.

PCV (Phenotypic coefficient of variations) which measure total relative variation was highest for number of unfilled grains/ panicle (26%), 1000 seed weight (20.64%) and seed yield (21.84%) while GCV was recorded high (>20%) for number of unfilled grains per panicle (20.72%), seed yield (20.62%) and test weight (20.46%) indicating higher contribution of number of unfilled grains/ panicle, seed yield and 1000 seed weight towards genetic variability and thereby suggesting that the parents chosen on the basis of these characters may be utilized in the crossing programme for obtaining good transgressivesegregants. Similar findings were recorded earlier by Khatun *et al.* (2015) for unfilled grains per panicle, Kishore *et al.* (2015) for 1000 seed weight and grain yield.

PCV and GCV values were moderate for the traits *viz.*, number of filled grains/ panicle (PCV: 13.59, GCV:15.05) and effective bearing tillers/ plant (PCV: 17.09, GCV:19.07) indicating less variability for the traits in the experimental material and therefore simple selection may not be rewarded.

Heritability is the proportion of phenotypic variation in a population that is due to genetic variation between individuals. It analyses the relative contributions of differences in genetic and non-genetic factors to the total phenotypic variance in a population. The genetic advance is a product of the heritability and selection differential expressed in terms of phenotypic standard deviation of the trait concerned. Heritability values in conjunction with selection differential are more effective as they indicate the expected genetic gain resulting from selection.

High heritability with high GAM (genetic advance as percent of mean) was observed for effective bearing tillers/ plant (H: 80.36; GA:31.56), number of filled grains/ panicle (H: 81.48; GA:25.27), number of unfilled grains/ panicle (H: 63.52; GA:31.56),1000 seed weight (H: 98.30; GA:41.79) and grain yield (H: 89.11; GA:40.09) indicating the additive gene action plays an important role in the inheritance of these parameters, hence, simple selection would be rewarding.

Hossain *et al.* (2014), Ria *et al.* (2015) reported similar results for the traits filled grains per panicle and effective bearing tillers per plant, respectively.

High/moderate heritability and low genetic advance was recorded for the traits *viz*., days to maturity (H: 87.25; GA:8.72), SCMR (H:55.67 GA: 6.91), panicle length (H: 40.64; GA:8.23) and harvest index (H: 73.06; GA:15.90) indicating the influence of non- additive gene actionin the inheritance of above said traits. Hence, improvement in these characters can be brought by exploitation of non-additive genetic variance through hybridization and selection.Similar results were reported by Kumar *et al.* (2014) for days taken for maturity and Satya and Jebaraj for panicle length in rice crop.

In this study, direct effect of grain yield was positive and high for effective bearing tillers/ plant (g: 2.004, p: 0.604), 1000 seed weight (g: 1.5901, p: 0.3093), harvest index (g: 1.044, p: 0.1911), number of filled grains/ panicle (g: 0.5644, p: 0.5030) and plant height (g: 0.5239, p: 0.1442) at genotypic level in the order of decreasing magnitude. Whereas, negative direct effects were observed for panicle length (g:0.5014, p: 0.0533). Positive genotypic direct effect with grain yield was recorded with days taken for maturity (g: 0.9580), while days taken for 50 percent flowering (g:1.2976) with negative direction at genotypic level. Whereas, the direct effects were positive with SCMR (rp: 0.0207) and number of unfilled grains/ panicle (rp: 0.5030) at phenotypic level. The findings of Sudharani *et al.* (2012) were in the line with this study findings for plant height, harvest index, number of filled grains/ panicle and days taken for 50 percent flowering and Saikumar *et al.* (2014) for 1000 seed weight. Reddy *et al.* (2013) and Kumar and Verma (2015) reported negative and positive direct effects for days taken for 50 percent flowering and panicle length respectively.

Knowledge of interrelationships among different characters is very much essential to plan for an effective selection criteria in plant breeding programmes. Generally direct selection for yield or amylose content is not aimed at in view of the complex nature of these characters besides effect of environmental interactions. Correlation studies permit only a measure of relationship between pair of traits. The actual contribution of

Table 1. Analysis of variance for yield and quality attributes in rice

S.No	Character	RMSS	TMSS	EMSS
1	Days to 50% flowering	0.27	63.26**	4.77
2	Days to maturity	0.62	65.31**	3.44
3	Plant height (cm)	1.14	40.32**	2.58
4	Ear bearing tillers per plant	0.06	5.74**	2.07
5	Panicle length (cm)	0.68	15.89**	1.47
6	Filled grains per panicle	64.57	1014.89**	61.70
7	Un-filled grains per panicle	2.40	33.22**	5.44
8	SCMR	5.97	11.88**	2.74
9	Harvest index (%)	14.67	74.09**	9.22
10	Test weight (g)	0.08	24.26**	0.17
11	Grain yield (g/p)	20.51	141.80**	5.71

Table 2. Mean, Coefficient of variability, Heritability and Genetic advance as % of mean for yield and yield components in rice

S.No	Character	General mean	PCV	GCV	H^2	GAM	S,E	CD(5%)	CV(%)
1	DFF	90.5	6.52	5.93	82.74	11.12	1.73	5.05	2.71
2	DM	122.6	4.84	4.53	87.56	8.73	1.48	4.31	1.7
3	PH	74.98	6.66	5.7	73.16	10.05	1.83	5.33	3.45
4	EBTS	15.42	18.38	16.22	77.81	29.47	0.94	2.75	8.66
5	PL	20.83	10.13	6.35	39.4	8.22	1.16	3.38	7.88
6	FGP	160.78	14.27	12.69	79.13	23.27	7.41	21.59	6.52
7	IFGP	17.68	26.68	21.61	65.62	36.07	1.95	5.69	15.64
8	TW	16.64	18.12	17.92	97.71	36.49	0.32	0.93	2.73
9	SPAD	45.3	6.22	4.68	56.64	7.26	1.31	3.82	4.1
10	HI	60.98	10.85	9.35	74.15	16.58	2.38	6.93	5.52
11	GY	40.16	21.21	20.07	89.61	39.15	1.94	5.65	6.83

Table 3.Phenotypic (r_p) and Genotypic (r_g) correlation coefficients among grain yield and yield components in rice

		DFF	DM	PH (cm)	EBTS/P	PL (cm)	FG/P	IFG/P	SCMR	HI (%)	TW(g)	GY/P (g)
DFF	G	1.000	0.996**	-0.398*	0.184	-0.517**	0.006	-0.068	-0.606**	-0.092	0.073	0.462**
	P	1.000	0.976**	-0.423**	0.255	-0.341*	0.014	-0.091	-0.417**	-0.055	0.081	0.421**
DM	G		1.000	-0.395*	0.209	-0.525**	-0.018	-0.038	-0.511**	-0.145	0.058	0.385*
	P		1.000	-0.414**	0.249	-0.314*	-0.017	-0.103	-0.425**	-0.109	0.058	0.354*
PH (cm)	G			1.000	-0.503**	0.840**	0.084	0.124	-0.198	0.114	0.131	-0.204
	P			1.000	-0.452**	0.420**	0.048	0.178	-0.025	0.058	0.107	-0.210
EBTS/Plant	G				1.000	-0.388*	0.288	-0.104	0.328*	-0.084	-0.667**	0.646**
	P				1.000	-0.396*	0.158	-0.117	0.028	0.029	-0.499**	0.568**
PL (cm)	G					1.000	0.096	0.456**	0.339*	0.092	0.046	-0.448**
	P					1.000	0.199	0.142	0.037	-0.129	-0.006	-0.269
FG/P	G						1.000	0.235	0.398*	0.526**	-0.624**	0.523**
	P						1.000	0.126	0.219	0.403**	-0.577**	0.515**
IFG/P	G							1.000	-0.188	0.233	-0.455**	-0.064
	P							1.000	0.097	0.046	-0.362*	-0.124
SCMR	G								1.000	0.653**	-0.405**	0.199
	P								1.000	0.338*	-0.271	0.007
HI (%)	G									1.000	-0.248	0.458**
	P									1.000	-0.158	0.395*
TW (g)	G										1.000	-0.307
	P										1.000	-0.263
GY/P (g)	G											1.000
	P											1.000

** Significant at 1% ; * Significant at 5%

Table 4. Estimates of direct and indirect effects of yield component characters on grain yield in rice

Character		DFF	DM	PH (cm)	EBTS/P	PL (cm)	FG/P	IFG/P	SCMR	HI (%)	TW(g)	GY/P (g)
DFF	G	-1.2976	0.9542	-0.2085	0.3685	0.2590	0.0033	-0.0328	0.3953	-0.0956	0.1160	0.462**
	P	0.7737	-0.4775	-0.0609	0.1538	0.0181	0.0068	0.0011	-0.0086	-0.0105	0.0252	0.421**
DM	G	-1.2924	0.9580	-0.2071	0.4184	0.2631	-0.0104	-0.0184	0.3331	-0.1519	0.0929	0.385*
	P	0.7548	-0.4894	-0.0597	0.1504	0.0167	-0.0086	0.0013	-0.0088	-0.0207	0.0179	0.354*
PH (cm)	G	0.5163	-0.3788	0.5239	-1.007	-0.4210	0.0474	0.0599	0.1292	0.1185	0.2082	-0.204
	P	-0.3269	0.2027	0.1442	-0.2727	-0.0224	0.0239	-0.0022	-0.0005	0.0111	0.0330	-0.210
EBTS/Plant	G	-0.2386	0.2000	-0.2635	2.0040	0.1945	0.1623	-0.0500	-0.2135	-0.0877	-1.0610	0.646**
	P	0.1969	-0.1219	-0.0651	0.6041	0.0211	0.0794	0.0014	0.0005	0.0055	-0.1542	0.568**
PL (cm)	G	0.6704	-0.5027	0.4399	-0.7774	-0.5014	0.0541	0.2200	-0.2209	0.0966	0.0729	-0.448**
	P	-0.2636	0.1538	0.0606	-0.2389	-0.0533	0.1002	-0.0018	0.0007	-0.0246	-0.0018	-0.269
FG/P	G	-0.0077	-0.0177	0.0440	0.5765	-0.0480	0.5644	0.1131	-0.2595	0.5499	-0.9919	0.523**
	P	0.0105	0.0084	0.0068	0.0954	-0.0106	0.5030	-0.0016	0.0045	0.0770	-0.1785	0.515**
IFG/P	G	0.0882	-0.0367	0.0650	-0.2079	-0.2286	0.1324	0.4824	0.1223	0.2429	-0.7241	-0.064
	P	-0.0705	0.0502	0.0257	-0.0709	-0.0075	0.0632	-0.0127	0.0020	0.0087	-0.1121	-0.124
SCMR	G	0.7868	-0.4895	-0.1039	0.6563	-0.1699	0.2246	-0.0905	-0.6519	0.6818	-0.6444	0.199
	P	-0.3228	0.2078	-0.0035	0.0168	-0.0019	0.1102	-0.0012	0.0207	0.0645	-0.0838	0.007
HI (%)	G	0.1187	-0.1393	0.0594	-0.1684	-0.0463	0.2971	0.1122	-0.4255	1.0446	-0.3944	0.458**
	P	-0.0428	0.0531	0.0084	0.0176	0.0068	0.2026	-0.0005	0.007	0.1911	-0.0488	0.395*
TW (g)	G	-0.0946	0.0559	0.0686	-1.3372	-0.0230	-0.3521	-0.2197	0.2642	-0.2591	1.5901	-0.307
	P	0.0630	-0.0284	0.0154	-0.3012	0.0003	-0.2903	0.0046	-0.0056	-0.0301	0.3093	-0.263

Residual effect: 0.307; DFF: Days to 50% flowering, DM: Days to maturity, PH: Plant Height (cm), PL: Panicle length (cm), EBTS: Ear bearing tillers per plant, FG/P: Filled grains per panicle, IFG/P: Ill filled grains per panicle, SCMR: SPAD Chlorophyll Meter Reading,

HI:Harvest index (%), TW: Test weight(g)

Table 5. Summarization of results

S.No.	Genetic parameter	Results
From Variability studies		
1	High PCV and GCV	Unfilled grains per panicle, Test weight, seed yield
2	Moderate GCV and PCV	Number of filled grains per panicle, number of ear bearing tillers per plant
3	High heritability coupled with high genetic advance	Number of ear bearing tillers per plant, number of filled grains per panicle, number of unfilled grains per panicle, test weight and grain yield
4	Medium heritability with low genetic advance	Days to maturity, Panicle length and harvest index
From correlation studies		
5	Positive association of grain yield with	Number of ear bearing tillers per plant, test weight, harvest index, number of filled grains per panicle, plant height
6	Negative association of grain yield with	Panicle length
7	Positive direct effect of grain yield with	Days to maturity, number of ear bearing tillers per plant, number of filled grains per panicle and harvest index

an attribute and its influence through other characters could be arrived only by way of partitioning the correlation coefficient into direct and indirect effects by path coefficient analysis. This will be very much helpful in rationalizing the basis of selection more meaningfully in a breeding programme.

From the correlation studies on crosses, among grain yield attributes revealed that number of ear bearing tillers/ plant, number of filled grains/ panicle, harvest index, days taken for 50% flowering and days taken for maturity showed the importance of the traits in determining the grain yield and selection may be effective based on these traits to isolate high yielding genotypes.

Path coefficient analysis revealed that the traits, days taken for maturity, number of ear bearing tillers/ plant, number of filled grains/ panicle and harvest index had shown high positive direct effect as well as positive association with grain yield indicating that these traits should be considered as an important selection criteria in the rice improvement programme and direct selection for these traits was recommended for yield improvement. These results were in consonance with the findings of Islam *et al.* (2015), Bhadru *et al.* (2012) for and

Sudharani *et al.* (2012) for number of filled grains/ panicle, respectively.

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EFFECT OF RICE HUSK RESIDUE ON MAIZE IN MINNA, NIGERIA

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ABSTRACT

The experiment was conducted during the 2014 and 2015 cropping seasons to study the effect of the method (surface application and incorporation)and rate of application(0, 10 and 15 tons ha^{-1}) of rice husk-residue on maize plant height and yield indices. Incorporation of rice husk-residue at 15 tons ha^{-1} produced the tallest ($P \leq 0.05$) maize plants and longest maize cobs, but method of application of rice husk-residue had no significant effect on grain yield, stover yield and cob weight. Residue incorporation produced longer cobs than surface application. However, 15 tons ha^{-1} residue application rate resulted in the highest ($P \leq 0.05$) grain yield, cob length and cob weight. The study suggests that incorporation of rice husk-residue rather than surface application as mulch, at 15 tons ha^{-1} will ensure better maize performance in Minna, Nigeria.

KeyWords: Rice husk residue, plant height, maize yield, Nigeria

INTRODUCTION

Maize is staple food crop in Nigeria (IITA, 2006; Enujeke *et al.,* 2013), also an energy source in livestock feed. It is a major raw material in the production of beverages, corn oil, corn syrup and flakes (Adeyemo and Agele, 2010). However, in most Sub-Saharan African countries, maize yield is low (IITA, 2007). Hussaini and Khan (2002) noted that soil fertility status and management practice are among the factors that affect the productivity of maize. Inorganic fertilizers are often commonly applied as source of mineral nutrients required to enhance maize growth with a consequent increase in yield (Akinloye and Olaniyan, 2012). However, these mineral fertilizers are beyond the reach of most farmers because they are quite costly (Agyenim-Boateng*et al.,* 2006). Also, increase in soil acidity, nutrient imbalance and poor soil physical condition result from application of inorganic fertilizers over a long period of time (Ojeniyi, 2012). Under these conditions, it may be necessary to employ management practices that would minimize the cost of maintaining soil fertility, enhance crop growth and increase yields.

Crop residues are applied to the soil as organic amendments, rather than being regarded as agricultural waste (McKinney, 2004).

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They could be left on the soil surface, applied as mulch, burnt or chopped into smaller pieces and incorporated into the soil. Most crop residues unlike rice husk face competition especially as livestock feed and material for construction and fencing (Eze *et al.,* 2014b; Eze *et al.,* 2015b). Rice husk is a milling by-product from rice paddy processing. It is produced in appreciable quantity in rice producing communities worldwide (Giddel and Jivan, 2007). Application of crop residues, either as mulch or by incorporation increase soil productivity, improve crop growth and increase yields (Chiroma *et al*., 2003 & 2005;Eze *et al.,* 2014a and b & 2015b). The high cost of mineral fertilizers and the negative effects on soil physical and chemical properties associated with their use for a prolonged period of time necessitates the application of available, cheap crop residues to improve soil productivity and enhance crop growth and yields. Therefore, the study was taken to determine effect of crop residue management practice on the performance of maize.

MATERIALS AND METHODS

The field study was carried out during the 2014 and 2015 cropping seasons at the Teaching and Research Farm of Federal University of Technology, Minna to determine the effect of method and rate of application of rice husk-residue on maize plant height and yield indices. The experimental site is located on latitude 9^0 31' N and longitude 6^0 26' E with a mean annual rainfall of about 1,300 mm between April and October. The temperature of the study site varies from 24^0C to 33.5^0 C, particularly between March and June.The soils are predominantly sandy in nature and are developed from basement complex. Minna is located in the southern Guinea savanna zone of Nigeria.

A 2 x 3 factorial experiment consisting of two methods of application (surface application and incorporation) and three rates of application of rice husk-residue(0, 10 and 15 tons ha^{-1}) was conducted. The treatments were laid out in a randomized complete block design with each plot size of 4 mx 4 m and replicated four times. The treatment plots were maintained or fixed during the two years of the experiment.

Following the application of rice husk-residue, maize seeds (‘Oba super 1’ variety) were sown at a spacing of 0.75 x 0.50 m inter-row and intra-row, respectively. Two seedlings per stand were maintained at two weeks after planting (WAP). Recommended fertilizer practices (NPK at 90: 60: 60 kg ha^{-1} and weeding were followed. At physiological maturity (12 WAP), maize cobs were harvested, sun-dried for about two weeks and threshed.

Plant height was measured at seedling emergence, vegetative growth, tasseling and maturity stages following the standard procedures. Yield indices viz., grain yield, stover yield, cob length and cob weight were recorded.

Data collected was subjected to statistical analysis (Analysis of variance, ANOVA) at 0.05 level of probability using Statistix 8.0 software (Statistix, 2010). Duncan’s multiple range test was employed for mean separation where significant differences between means were found.

RESULTS AND DISCUSSION

Application of crop residue had significant effect on plant height at seedling emergence, vegetative growth, tasseling and maturity stages (Table 1). Incorporation of rice husk resulted in significantly ($P \leq 0.05$) taller maize plants than surface application during all the growth stages. Also, application of 15 tons ha^{-1} of rice husk produced the tallest maize plants. These observations were found to be consistent throughout the growing season and in the two-year study period (2014 and 2015). Incorporation of rice husk increased plant height considerably ($P \leq 0.05$) by a range of between 6% and 10 %, while its application at 15 tons ha^{-1} increased the height of plants by a range of between 10%and 33 %. Kumar and Goh (2000) noted that the benefits that accrue when crop residues are incorporated in the soil include replenishment of soil organic matter, faster mineralization to release essential nutrients for enhancement of crop growth and increase in yields.

Method of application of crop residue (rice husk) had no significant influence on grain yield, stover yield and cob weight of maize. However, it significantly affected the length of cobs

Table 1. Effect of method and rate of application of rice husk-residue on plant height (cm) of maize

Crop growth stages				
Treatment	**Seedling emergence**	**Vegetative growth**	**Tasseling**	**Maturity**
Application method (A)				
Surface	33.7b	112.8b	181.8b	178.6
bIncorporation	37.5a	126.2a	193.3a	194.2a
SE±	1.4	4.1	3.4	5.4
Application rate (B)				
0 t ha^{-1}	30.7c	94.0c	169.9c	173.3b
10 t ha^{-1}	35.7b	125.4b	191.8b	191.9a
15 t ha^{-1}	40.4a	139.2a	201.1a	194.0a
SE±	1.8	5.0	4.2	6.7
Interaction				
A x B	NS	NS	NS	NS

Means with different letter(s) on the same column are significantly (P d” 0.05) different at 0.05 level of probability; NS: Not significant

(Table 2). Incorporation of crop residue as soil organic amendment produced significantly ($P \leq 0.05$) longer cobs compared with surface application of residue, although the better crop growth and longer cobs that resulted from residue incorporation in this study did not translate to significantly higher grain and stover yields. It must be noted however, that incorporation of rice husk has the potential to improve crop yield judging from the fact that this

Table 2. Effect of method and rate of application of rice husk residue on yield parameters of maize

Grain yield Treatment	**Stover** (kg ha^{-1})	**yield** (kg ha^{-1})	**Cob length** (cm)	**Cob weight** (g/4 m^2)
Application method (A)				
Surface	5,166a	9,630a	14.0a	1,225a
Incorporation	5,712a	10,365a	14.4a	1,299a
SE±	352	671	0.33	61
Application rate (B)				
0 t ha^{-1}	4,261b	9,414a	13.2b	1,065b
10 t ha^{-1}	5,647a	9,893a	14.4a	1,323a
15 t ha^{-1}	6,409a	10,685a	14.9a	1.397a
SE±	431	822	0.4	75
Interaction				
A x B	NS	NS	NS	NS

Means with different letter(s) on the same column are significantly different at 0.05 level of probability
NS: Not significant

treatment produced significantly taller plants and longer cobs. Rate of application of crop residue had significant effect on maize yield parameters (Table 2). Application of 15 tons ha^{-1} of residue produced highest ($P \leq 0.05$) grain yield, cob length and cob weight compared with 0 and 10 tons ha^{-1} application rates. Fifteen tons ha^{-1} application rate increased grain yield by over 50% more than no application and by over 20% over 10 tons ha^{-1} application. It also increased cob length and cob weight by about 25% and 40 %, respectively. The better performance arising from returning crop residue to the soil is attributed to improvement of soil properties and supply of nutrients through mineralization of the applied crop residues (Abbasi *et al.,* 2009; Eze *et al.,* 2014a and b & Eze *et al.,*2015a & b). Thus, crop residues are not agricultural wastes, because these have unlimited potential for improving soil productivity and crop performance.

CONCLUSION

Rice husk incorporation produced tallest plants and longer cobs than surface application.Rice husk residue application at 15 tons ha^{-1} resulted in the tallest plants, highest grain yield and cob weiht, and longest cobs. Therefore, incorporation of rice husk-residue rather than surface application as mulch at 15 tons ha^{-1} is recommended for the enhancement of maize performance in Minna, Nigeria.

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ANNUAL PRODUCTION TRENDS IN TENERA HYBRIDS OF OIL PALM IN ANDHRA PRADESH

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ABSTRACT

Ten oil palm crosses (tenera) were evaluated for 10 harvest years for their growth and yield. Growth of oil palm crosses has not varied significantly among the crosses for palm height and girth. Palm height increment was more than three times from 6th year of harvest to 10th year of harvest, that is 1.00 m to 3.93 m. Annual palm height increment was at the rate of 0.3 to 0.35 m up to seventh harvest year but from eighth to tenth harvest years, palm height increment was at the rate of 0.47 to 0.58 m per year, percent height increment was higher at early harvest years than at later harvest years. Raise and fall in bunch production in every alternate year was the trend up to 9th harvest year. Bunch production and average bunch weight are in inverse relation. Increase in bunch production in a harvest year recorded decrease in average bunch weight of that production year. In the 10th harvest year, bunch production drastically reduced to 6.34 bunches, while average bunch weight in the10th harvest year was high (18.15 kg). The cross NRCOP-4 produced higher number of bunches (13.72) at the sixth harvest year, recording FFB yield of 190.23 kg palm^{-1} with productivity of 23.39t ha^{-1}.. There was an yield increment by increase in age of palms up to 11 years (8th harvest year). At the 8th harvest year mean per palm yield in the crosses reached to 181 kg recording a productivity of 22.26 t ha^{-1}. Yield increment was four times in the first four harvest years (17.97 to 86.74 kg palm^{-1}) where this period of production can be considered as yield incremental period and 5th to 8th harvest years, could be considered as yield stabilizing period because of less yield increment and stable production from the palms(124.76 to 181 kg palm^{-1}). Cumulative bunch production was higher in the cross NRCOP-4 (96.18) with an yield of 159.3 t ha^{-1} in ten harvest years. Commercial plantations should be planted with high quality seedlings having more productivity. Field performance of dura x pisifera crosses have to be evaluated regularly in comparative trials for notable yield improvement.

Key words: Oil palm yield, FFB production, annual bunch yield, Tenera Hybrids

INTRODUCTION

India is one of the major consumer of vegetable oils. India to get self- sustain for edible oil demands, oil palm (*Elaeis guineesis*) crop is best option to cut short the import duties to some extent, because oil palm is high perennial

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edible oil yielding plantation crop that has a greater advantage in terms of productivity *i.e.* 5-6 t ha^{-1} per year of palm oil and 0.5 t ha^{-1} per year of palm kernel oil, a much higher than the yields of traditional oilseed crops like sunflower, groundnut, sesame and soybean, etc., as these crops produce only 0.4-0.5 t ha^{-1} as they are short duration annual field crops. As oil palm is having 4-5 times higher yield advantage over traditional oil seed crops, it is being grown in Andhra Pradesh for the last 30 years (Rethinam and Chadda, 1992). In India, Andhra Pradesh occupies first place in oil palm area and production. Hence, there is every need to increase productivity in oil palm with development of hybrids for different climatic conditions of India and their suitability to different farming situations, so as to meet the increasing vegetable oil demands of the country. Besides high oil yielding potential, oil palm is one of the best carbon sinks for the present global warming situation. It can have 47.66 t ha^{-1} of carbon stock per year in standing crop with carbon sequestration potential of 174.93 t ha^{-1} (Bhagya and Suresh , 2018).

In the coming next four decades the world population is going to increase, to meet the rapid growth of food demand in the developing countries like India, in conjunction with the high calorie content, oil products have been a major component of the increase achieved in food consumption (kcal/person/year) with 30-35 million tonnes of palm oil demand as against present global production. There is every need to evaluate the oil palm production potential in different farming situations apart from irrigated and high input management conditions. Tenera hybrids have to be tested in all types of degraded soils and also under rainfed conditions for its yield potential in the country. Annual bearing potential and yield increment assessment are prime parameters which are to be assessed to have sound knowledge on productivity and sustainability with long term income generation under field condition.

MATERIALS AND METHODS

During the year 2007, ten new oil palm (D X P) cross combinations were planted to evaluate their production performance. The experiment was laid out in a Randomized Block Design (RBD) with three replications at Horticultural Research Station, Vijayarai, West Godavari District of Andhra Pradesh (16.81^{0}N, 81.03^{0}E). (Normal average annual rainfall of the region was in the range of 800-900 mm). Ten crosses (NRCOP-1 to NRCOP-10) developed at Indian Institute of Oil palm Research (IIOPR), Pedavegi, West Godavari District of Andhra Pradesh (Table:1) were used for evaluation. Research trial was taken up with six palms at 9 m x 9 m spacing accommodating 123 palms per hectare. The plantation was under irrigated condition with 1200:600:1200 g of N: P: K application per palm in four splits at quarterly intervals and 500 g of magnesium sulphate and 100 g of borax application per palm in two splits in a year. All the recommended package of practices were followed.Observations were recorded by following standard methods. All the mature fruit bunches were harvested at 11-13 days interval, starting from 4th year after planting

Table 1. Different cross combinations and their parents

CROSS COMBINATIONS	PARENTS	CROSS COMBINATIONS	PARENTS
NRCOP-1	78D X 435P	NRCOP-6	173D X 435P
NRCOP-2	90D X 577P	NRCOP-7	183D X 577P
NRCOP-3	158D X 116P	NRCOP-8	70D X 577P
NRCOP-4	131D X 435P	NRCOP-9	28D X 435P
NRCOP-5	5D X 577P	NRCOP-10	345D X 577P

to 13 years (10 harvest years). Every bunch was weighed together with loose fruits using a balance mounted on a tripod. The total bunch weight was divided by the number of recording palms to obtain total bunch weight per palm which was then multiplied by the stand per hectare to obtain total bunch weight (FFB yield) per hectare per year. FFB yield recorded for 10 harvest years were totalled to get cumulative yield. All the data were summarised according to treatments and subjected to statistical analysis, least significant differences (LSD) test, at significance level of 5%.

RESULTS AND DISCUSSION

Palm Height (m)

Ten (D X P) oil palm crosses were evaluated for 10 harvest years (4 to 13 years after planting). First three years from the date of planting was pre bearing period. From 4th to 13 years after planting yields were recorded to evaluate the productivity of crosses. Height and girth were taken from 3rd harvest year (6th year after planting) onwards. There was no significant variation recorded for height of palms among the crosses except in 3rd year of harvesting (6 years after planting). In the third year of harvesting, NRCOP-4 recorded significantly higher palm height (1.2 m) which was on par with the crosses NRCOP-1, 7 and 8 (Table 2). Palm height increment was three times from 6th year of harvest to 10th year of harvesting, that is 1.00 m to 3.93 m (Fig. 1). Annual palm height increment was at the rate of 0.3 to 0.35 m up to seventh harvest year but from eighth to tenth harvest years palm height increment was at the rate of 0.47 to 0.58 m per year, the height increment was up to 27% when the palms crossing the age from 3rd to 4th year of harvest, by 4th to 5th harvest years it was only 20% increase. From 5th harvest year onwards to 10th harvest year per cent height increment was lower, that is only 15%. As per the data depicted in the Fig.1, growth rate of palms will get stable from 8th year onwards. Linear height increment was recorded during the yield assessment period. These results are in conformation with the results of Indian Institute of Oil Palm Research (IIOPR) annual reports (2017-18).Palm height after 8 years of field planting ranged from 1.67 to 2.78 with trial mean of 2.12m (Ibrahim Wesiu Arolu *et al*., 2017).

Girth of Palm (m)

As like palm height, girth of the palms were also not varied significantly among the crosses in all the years of experimental period (3rd year of harvesting to 10th year of harvesting (Table 2). Girth of palms at 3rd year of harvesting was 1.24 m and it was increased by two times by 4th year of harvesting 2.57 m and by 10th year of harvesting it was 3.93 m that is three times to 3rd year of harvesting (Fig. 2).

Sex Ratio

Among the crosses, the sex ratio did not vary significantly in their 10 years of the production period. Sex ratio was higher (0.65 to 0.75) in early harvest years, in later harvest years it was 0.50 to 0.60 (Table 3).

Fresh Fruit Bunch (FFB) Production

Fresh fruit bunches produced in 10 harvest years (4 years after planting to 13th year of planting) was shown in Table 5. Significant variation among the crosses for bunch production per palm per year was recorded in 4th, 7th and 9th harvest years. Remaining seven years of harvesting period, ten crosses have not varied significantly for bunch production per palm per year. In 4th year of production, NRCOP-4 produced highest number of bunches per palm per year (10.06) which was on par with the cross NRCOP-8 (8.04) (Table 4). In 7th harvest year NRCOP-2 produced highest number of bunches per palm per year (12.27) which was on par with the crosses NRCOP-3, 4, 5, 9 and 10 (Table 4). In 9th harvest year NRCOP-6 recorded highest number of bunches per palm per year (11.83) it was on par with the crosses NRCOP-4 and 2. Among the crosses, bunch production in the first 4 harvest years was in the range of 3.37 to 10.06 bunches per palm per year, from 5th harvest year to 9th harvest year bunch production was in the range of 8.67 to 13.72 bunches per palm per year. In the 10th harvest year bunch production was in the range of 4.8 to 8.30 bunches per palm per pear (Table 4). Oil palm produces stable yield of 30 t ha^{-1} up to 24 years age of palms (Madhavi Latha *et al.*, 2016)

As illustrated in Fig. 2, trend for bunch production shows raise and fall in every alternate year in all the 10 harvest years. Bunch production per palm per year goes to peak at 6th harvest year with 11.72 bunches. In the first four years of harvesting bunch production per palm per year was in the range of 6 to7 and from 5th to 9th harvest years bunch production was in the range of 10-11 bunches per palm per year (Fig. 2).In the 10th harvest year bunch production was reduced to 6.34 which was as low as 4th year bunch production. Cumulative bunch production was recorded highest in the cross NRCOP-4, which was 96 bunches per each palm. Among the ten crosses,50% of the crosses produced more than 90 bunches in 10 harvest years (Fig.3).NRCOP-7 recorded lowest cumulative bunch production per palm (78.86) for the last 10 harvest years (Fig. 3).

Average Bunch Weight (kg)

Data recorded for average bunch weight

in 10 harvest years reflect that in the first three years and 5th and 10th harvest years, there were no significant variations for average bunch weight, in 4th and 6th harvest years NRCOP-4 recorded significantly highest average bunch weight of 14.37 kg and 14.18 kg, respectively.

In 7th and 9th harvest years, NRCOP-1 recorded highest average bunch weight of 18.09 and 18.33 kg, respectively (Table 5). In 8th harvest year NRCOP-2 recorded highest average bunch weight of 14.91 kg and it was on par with all the crosses except NRCOP-3 and 6. Average bunch weight of 2.46 kg recorded in the first harvest year was raised to 18.15 kg in the 10th harvest year (Fig. 3). In the first four harvest years, the average bunch weight was linearly increased over 5th year. There was 13% reduction in the average bunch weight again in the next 2 years and there was linear increment in average bunch weight up to 7th harvest year. Again in the 8th harvest year average bunch weight was reduced by 12 %, but in 9th and 10th harvest years, average bunch weight increased in all the crosses. The Fig.3 reflects inverse relation between number of bunches produced and bunch weight in all the crosses.Asphotosynthates produced by the palms might be at constant level, distribution of these photosynthetic assimilates to more number of bunches in a harvest year lead to lower average bunch weights in that harvest year. With increase in age of palms the sex ratio decreases so that number of bunches produced palm^{-1} year^{-1} are reduced but average bunch weight will be increased (Rethinam, 1998)

FFB YIELD (kg palm^{-1} year^{-1} and t ha^{-1})

Fresh fruit bunch yield data recorded for 10 harvest years reflect that, in the first three harvest years and 10th year of harvest results were non significant for fresh fruit bunch yield per palm per year among the crosses. From 4th year of harvest to 9th year of harvest, NRCOP-4 recorded the highest FFB yield per palm per year. In 8th and 9th harvest years FFB production reached peak that is 210.21 and 210.56 kg, respectively per palm per year. In the 7th year of harvest, almost all the crosses recorded on par FFB yield with NRCOP-4 except NRCOP-7 and NRCOP-10 crosses, wherein recorded the lowest FFB yield of 141.96 and 145.52 kg per palm per year. By 8th harvest year, the crosses recorded 181 kg of mean fresh fruit bunch yield per palm with a production potential of 22.26 t ha^{-1} (Fig. 4) .Oil palm breeders estimate potential yields of 18 t/ acre (Corley and Tinker, 2003).These results are also in concurrence with the results of Rajanaidu *et al*.(2013) where, new D x P developed for low height based on MPOB-Nigerian germplasam recorded FFB yield of 194 to 231 kg palm^{-1} year^{-1}. FFB yield per palm per year in the first and second harvest years was increased by 33% and 32%, respectively. From 3rd harvest year to 4th harvest year FFB production was raised meagerly by 5%. Again from 4th harvest year to 5th harvest year FFB production per palm increased by 30% .From 5th to 6th, 6th to 7th and 7th to 8th harvest years, FFB production increased by 11% to 12% only. So it can be considered that first to fifth harvest years are yield incremental period and 6th, 7th and 8th harvest years are yield stabilizing years because production was raised only 11% to 12%. From 9th harvest year onwards, FFB yield production per palm per year showed declining trend, from 8th harvest year to 9th harvest year there was 9% reduction in FFB production per palm and it was further reduced to 30% in 10th harvest year. FFB production among the palms was linearly increased from first year of harvest to eighth year of harvest. Fig: 4 depicts that at 8th harvest year FFB production reached peak that is 181 kg per palm per year with 22.26 t ha^{-1} FFB yield. Production potential of oil palm increases with increase in age of the palm up to 12 years age and then plantation comes to yield stabilization (Madhavi Latha *et al* ., 2016) and Rethinam,1998). Application of either compost or fertilizer alone increased fresh fruit bunch yield from 23.24 to 25.49 t ha^{-1} (Lai Guan Yi *et al.,* 2019)

Cumulative fresh fruit bunch yields(FFB) reveal that NRCOP-4 recorded highest FFB yield of 159.34 t ha^{-1} with a production of 96.18 bunches in 10 harvest years(Fig. 3). Among the ten crosses, four crosses recorded more than 140 t ha^{-1} FFB yield in 10 harvest years (Fig.3). The cross NRCOP-7 recorded the lowest FFB yield of 121.13 t ha^{-1}. Production of more number of bunches with high average bunch weight is the reason for more productivity in the cross NRCOP-4.The main objective of oil palm breeding is to achieve high fresh fruit bunch and high oil yields(Rajanaidu *et al.,* 2013)

FFB productivity was 25.90 t ha^{-1} in NRCOP-4 cross at 9th harvest year, however, the cross already reached 25.86 t ha^{-1} FFB yield at 8th harvest year. From 5th harvest year the cross NRCOP-4 recorded more than 21 t ha^{-1} (Table 7) The data reveals that FFB yields in oil palm will be 2.21 t ha^{-1} in first harvest year and it reached to 22.26 t ha^{-1} in the 8th harvest year (Fig. 4). In oil palm, yield increment was 4 times from first harvest year to third harvest year (17.97 kg to 82.4 kg of FFB palm^{-1}). Overall, FFB production increment was 85% in the first five harvest years (2.21 to10.66 t ha^{-1}), hence, that this production period can be considered (1st to 5th) as yield incremental period. From 5th to 8th harvest years, there was only 12 to 13 % yield increment, as FFB yield increment was less and stable in later harvest years (5th to 8th) so that this production period can be considered as yield stabilizing period with a production of 15 to 22 t ha^{-1}. The crosses recording FFB yield of more than 22 t ha^{-1} at 6th harvest year have better prospects for cultivation in Andhra Pradesh (Sanjeevraddi *et al.,* 2016). An increase of more than 30% oil yield was realised with switching over from dura to the tenera planting material (Kushairi and Mohd Din Amiruddin, 2020).

Table 2. Inter-annual dynamics on palm height (m) and girth (m) of tenera hybrids

Age of Palm	**6 Years** (2012-13)		**7 Years** (2013-14)		**8 Years** (2014-15)		**9 Years** (2015-16)		**10 Years** (2016-17)		**11 Years** (2017-18)		**12 Years** (2018-19)		**13 Years** (2019-20)	
Cross combinations	Third harvest year		Fourth harvest year		Fifth harvest year		Sixth harvest year		Seventh harvest year		Eighth harvest year		Ninth harvest year		Tenth harvest year	
	Height	Girth	Height	Girth	Height	Girth	Height	Girth	Height	Girth	Height	Girth	Height	Girth	Height	Girth
NRCOP-1	1.15	1.23	1.35	2.58	1.78	2.77	2.01	2.86	2.56	2.93	3.25	2.96	3.93	3.02	4.29	2.84
NRCOP-2	0.94	1.28	1.22	2.44	1.8	2.62	1.97	2.66 2	2.86	2.42	2.86	2.89	2.86	3.64	2.74	2.74
NRCOP-3	0.85	1.12	1.2	2.54	1.3	2.75	1.59	2.78	2.1	2.87	2.67	2.94	3.19	2.95	3.65	2.78
NRCOP-4	1.2	1.11	1.39	2.70	1.77	2.77	2.04	2.84	2.6	3.00	3.25	3.12	3.46	3.19	4.33	2.92
NRCOP-5	0.96	1.34	1.38	2.53	1.58	2.97	1.86	2.99	2.36	3.10	2.94	3.14	3.42	3.19	3.92	2.97
NRCOP-6	0.95	1.21	1.44	2.54	1.71	2.74	2.13	2.76	2.24	2.91	2.81	2.92	3.17	2.92	3.81	2.80
NRCOP-7	1.19	1.32	1.38	2.66	1.73	2.85	1.94	2.79	2.5	2.95	3.11	2.97	3.47	3.00	4.23	2.89
NRCOP-8	1.09	1.13	1.53	2.64	1.56	2.80	2.18	2.78	2.37	2.85	2.9	2.89	3.73	2.94	4.03	2.77
NRCOP-9	0.83	1.43	1.49	2.56	1.79	2.69	1.98	2.67	2.21	2.83	2.74	2.95	3.17	3.21	3.76	2.79
NRCOP-10	0.89	1.23	1.24	2.54	1.7	2.71	2.04	2.62	2.19	2.85	2.76	2.90	3.12	2.90	3.69	2.73
CD (@5%)	0.22	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	13.13															

Table 3. Annual production performances of oil palm crosses on sex ratio

Age of Palm	**6 Years** (2012-13)	**7 Years** (2013-14)	**8 Years** (2014-15)	**9 Years** (2015-16)	**10 Years** (2016-17)	**11 Years** (2017-18)	**12 Years** (2018-19)	**13 Years** (2019-20)
Cross combinations	Third harvest year	Fourth harvest year	Fifth harvest year	Sixth harvest year	Seventh harvest year	Eighth harvest year	Ninth harvest year	Tenth harvest year
NRCOP-1	0.59	0.73	0.56	0.53	0.53	0.74	0.54	0.52
NRCOP-2	0.57	0.70	0.53	0.53	0.53	0.75	0.47	0.62
NRCOP-3	0.57	0.70	0.55	0.43	0.43	0.69	0.58	0.55
NRCOP-4	0.61	0.83	0.74	0.53	0.52	0.85	0.63	0.66
NRCOP-5	0.57	0.88	0.46	0.50	0.50	0.83	0.63	0.56
NRCOP-6	0.61	0.82	0.55	0.67	0.42	0.76	0.51	0.68
NRCOP-7	0.59	0.76	0.65	0.43	0.41	0.76	0.67	0.62
NRCOP-8	0.62	0.63	0.49	0.57	0.47	0.65	0.57	0.71
NRCOP-9	0.62	0.69	0.60	0.47	0.47	0.74	0.53	0.68
NRCOP-10	0.58	0.68	0.66	0.47	0.40	0.77	0.47	0.57
CD @ 5%	NS	0.608	NS	NS	NS	NS	NS	NS
CV (%)		4.74						

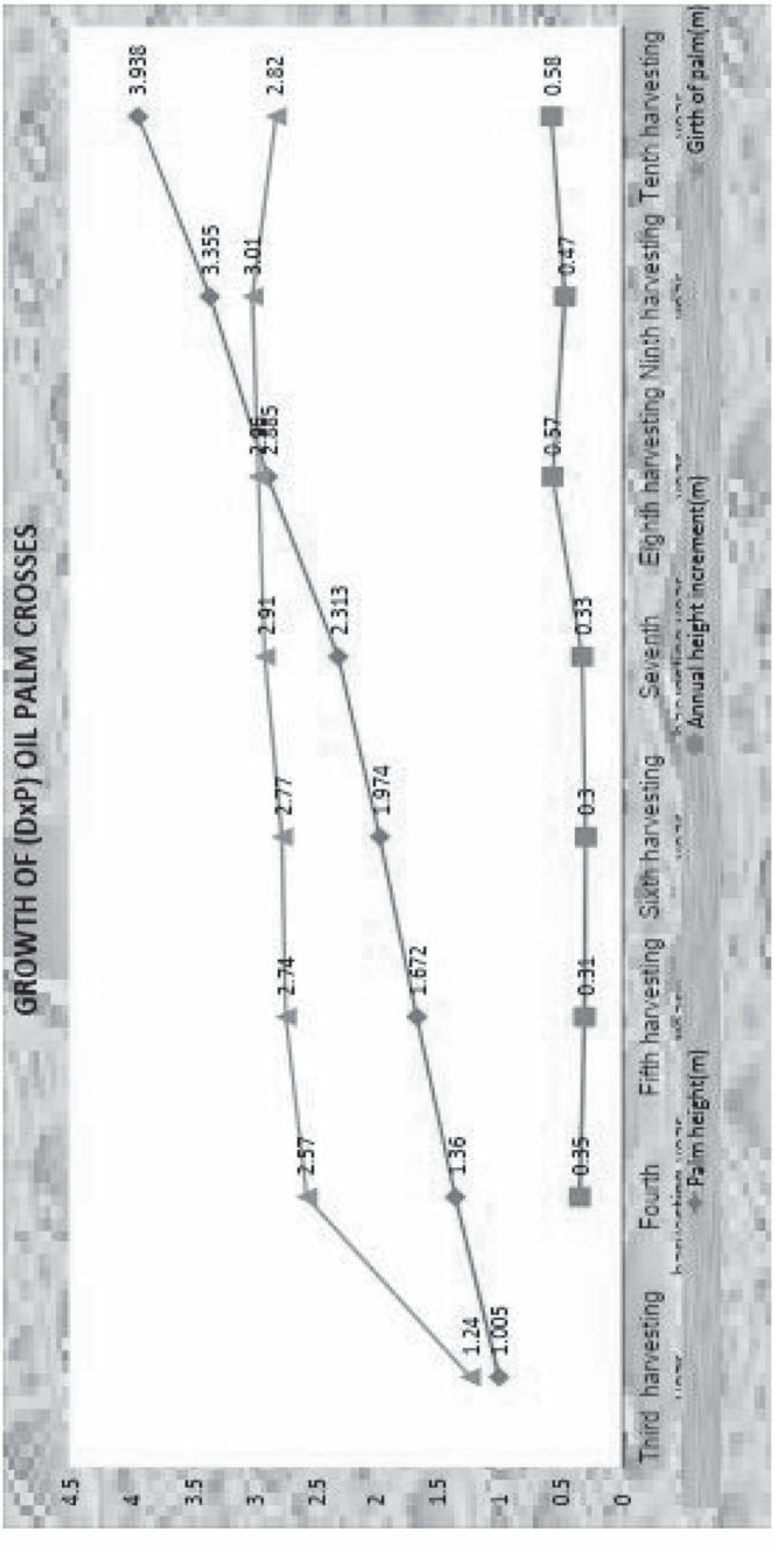

Fig. 1. Inter annual dynamics on palm height, girth and annual height increment in tenera hybrids

Table 4. Annual production performance of oil palm (d x p) cross combinations on number of bunches produced per palm

Age of Palm	4 Years (2010-11)	5 Years (2011-12)	6 Years (2012-13)	7 Years (2013-14)	8 Years (2014-15)	9 Years (2015-16)	10 Years (2016-17)	11 Years (2017-18)	12 Years (2018-19)	13 Years (2019-20)
Cross combinations	First harvest year	Second harvest year	Third harvest year	Fourth harvest year	Fifth harvest year	Sixth harvest year	Seventh harvest year	Eighth harvest year	Ninth harvest year	Tenth harvest year
NRCOP-1	9.73	8.34	7.1	5.46	10.04	11.28	9.05	11.11	10.11	6.22
NRCOP-2	7.36	6.33	6.48	7.29	9.81	11.31	12.27	12.39	11.32	8.30
NRCOP-3	7.15	6.13	7.63	5.77	10.67	11.89	10.83	10.77	8.67	5.89
NRCOP-4	6.28	5.36	7.85	10.06	12.61	13.72	10.67	12.67	11.80	5.16
NRCOP-5	4.89	4.19	8.19	3.37	11.09	11.86	11.28	12.33	10.91	5.99
NRCOP-6	7.50	6.54	8.51	5.39	10.93	12.28	10.45	12.61	11.83	7.06
NRCOP-7	5.46	4.65	7.79	4.33	10.60	11.49	9.7	10.39	9.65	4.80
NRCOP-8	7.74	6.65	8.09	8.04	10.80	11.22	10.05	10.66	9.22	6.78
NRCOP-9	8.31	7.13	6.77	6.44	10.97	11.33	11.72	12.72	10.44	7.11
NRCOP-10	8.95	7.67	7.54	6.29	10.47	10.78	10.77	11.61	10.65	6.17
CD @ 5%	NS	NS	NS	2.13	NS	NS	1.78	NS	2.97	NS
CV (%)				19.68			9.71		18.61	

Table 5. Annual production performance of oil palm (d x p) cross combinations on average bunch weight (kg)

Age of Palm	4 Years (2010-11)	5 Years (2011-12)	6 Years (2012-13)	7 Years (2013-14)	8 Years (2014-15)	9 Years (2015-16)	10 Years (2016-17)	11 Years (2017-18)	12 Years (2018-19)	13 Years (2019-20)
Cross combinations	First harvest year	Second harvest year	Third harvest year	Fourth harvest year	Fifth harvest year	Sixth harvest year	Seventh harvest year	Eighth harvest year	Ninth harvest year	Tenth harvest year
NRCOP-1	2.34	5.65	12.6	13.78	10.10	13.32	18.09	13.57	18.33	18.28
NRCOP-2	2.54	3.87	10.5	12.64	10.93	10.68	13.49	14.91	12.66	16.66
NRCOP-3	2.50	4.48	9.63	13.93	10.63	11.64	15.84	12.00	15.21	17.61
NRCOP-4	2.33	4.54	9.47	14.37	13.87	14.18	15.92	14.46	17.82	19.10
NRCOP-5	2.66	3.57	11.2	14.00	12.43	12.17	15.27	13.40	15.19	17.70
NRCOP-6	2.60	4.58	13.0	12.75	11.33	11.94	15.69	11.68	15.02	17.71
NRCOP-7	2.68	3.25	11.5	13.30	11.50	11.16	15.11	14.49	16.23	18.44
NRCOP-8	2.52	3.54	9.57	9.43	11.23	13.58	15.28	14.56	17.49	19.56
NRCOP-9	2.25	4.81	10.2	14.21	12.07	13.15	15.39	12.61	16.31	19.36
NRCOP-10	2.27	4.22	11.7	13.23	10.60	11.01	13.75	13.34	14.49	17.14
CD @ 5%	NS	NS	NS	2.17	NS	2.13	2.36	1.81	3.14	NS
CV (%)				9.56		10.14	8.97	7.76	12.50	

Table 6. Annual production performance of oil palm (d x p) cross combinations on fresh fruit bunch weight (kg palm^{-1} year^{-1})

Age of Palm	**4 Years** (2010-11)	**5 Years** (2011-12)	**6 Years** (2012-13)	**7 Years** (2013-14)	**8 Years** (2014-15)	**9 Years** (2015-16)	**10 Years** (2016-17)	**11 Years** (2017-18)	**12 Years** (2018-19)	**13 Years** (2019-20)
Cross combinations	First harvest year	Second harvest year	Third harvest year	Fourth harvest year	Fifth harvest year	Sixth harvest year	Seventh harvest year	Eighth harvest year	Ninth harvest year	Tenth harvest year
NRCOP-1	22.76	47.12	89.63	75.22	105.35	149.37	167.14	200.59	187.39	114.05
NRCOP-2	18.70	24.50	68.34	92.16	106.88	121.79	161.38	171.09	139.09	137.84
NRCOP-3	17.89	27.46	73.49	80.38	112.85	137.32	165.87	150.02	133.12	103.35
NRCOP-4	14.63	24.33	74.35	128.24	174.03	190.23	172.06	210.21	210.56	96.97
NRCOP-5	13.01	14.96	91.76	105.69	138.90	141.56	172.05	171.74	165.59	105.70
NRCOP-6	19.51	29.95	101.82	77.50	124.73	146.06	159.38	194.01	179.21	124.88
NRCOP-7	14.63	15.11	89.82	57.61	121.88	129.61	141.96	166.37	154.44	89.77
NRCOP-8	19.51	23.54	77.43	75.88	120.60	151.07	153.89	187.52	161.31	136.81
NRCOP-9	18.70	34.30	69.13	91.52	131.53	146.02	175.96	195.99	170.58	135.81
NRCOP-10	20.33	32.37	88.13	83.22	110.80	118.01	145.52	162.55	155.78	105.90
CD (@5%)	NS	NS	NS	33.90	30.59	29.75	19.88	26.52	55.32	NS
CV (%)				22.61	14.30	12.2	7.19	8.47	20.54	

Table 7. Annual production performance in (d x p) cross combinations of oil palm on fresh fruit bunch yield (tonnes ha^{-1})

Age of Palm	**4 Years** (2010-11)	**5 Years** (2011-12)	**6 Years** (2012-13)	**7 Years** (2013-14)	**8 Years** (2014-15)	**9 Years** (2015-16)	**10 Years** (2016-17)	**11 Years** (2017-18)	**12 Years** (2018-19)	**13 Years** (2019-20)
Cross combinations	First harvest year	Second harvest year	Third harvest year	Fourth harvest year	Fifth harvest year	Sixth harvest year	Seventh harvest year	Eighth harvest year	Ninth harvest year	Tenth harvest year
NRCOP-1	2.8	5.79	11.02	9.25	12.95	18.37	20.18	24.67	23.05	14.03
NRCOP-2	2.3	3.01	8.40	11.33	13.14	14.98	19.84	21.04	17.11	16.93
NRCOP-3	2.2	3.37	9.03	9.88	13.88	16.89	20.40	18.47	16.37	12.71
NRCOP-4	1.8	2.99	9.14	15.77	21.40	23.39	21.16	25.86	25.90	11.93
NRCOP-5	1.6	1.83	11.28	12.99	17.08	17.41	21.16	21.12	20.37	13.00
NRCOP-6	2.4	3.68	12.52	9.53	15.34	17.96	19.60	23.86	22.04	15.36
NRCOP-7	1.8	1.85	11.04	7.08	14.99	15.94	17.46	20.46	19.0	11.51
NRCOP-8	2.4	2.89	9.52	9.33	14.83	18.58	18.92	23.07	19.84	16.83
NRCOP-9	2.3	4.21	8.5	11.25	16.17	17.96	21.64	24.11	20.98	16.69
NRCOP-10	2.5	3.98 10.83	10.23	13.62	14.51	17.89	19.99	19.16	13.03	
CD (@5%)	NS	NS	NS	0.84	3.75	3.65	2.54	3.26	7.46	NS
CV (%)				3.92	12.52	12.12	5.85	8.47	18.9	

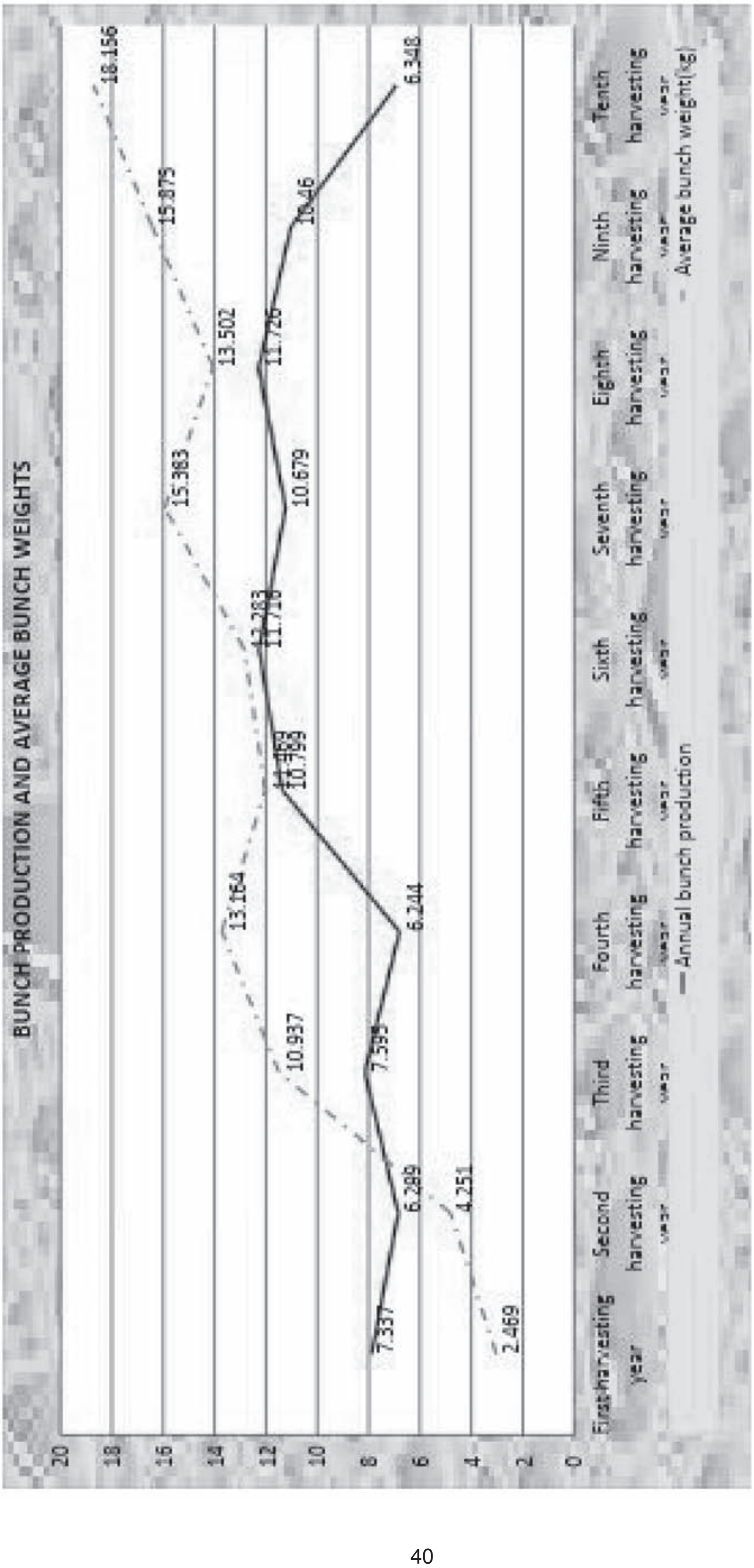

Fig. 2. Bunch production and average bunch weights of oil palm crosses in their production period

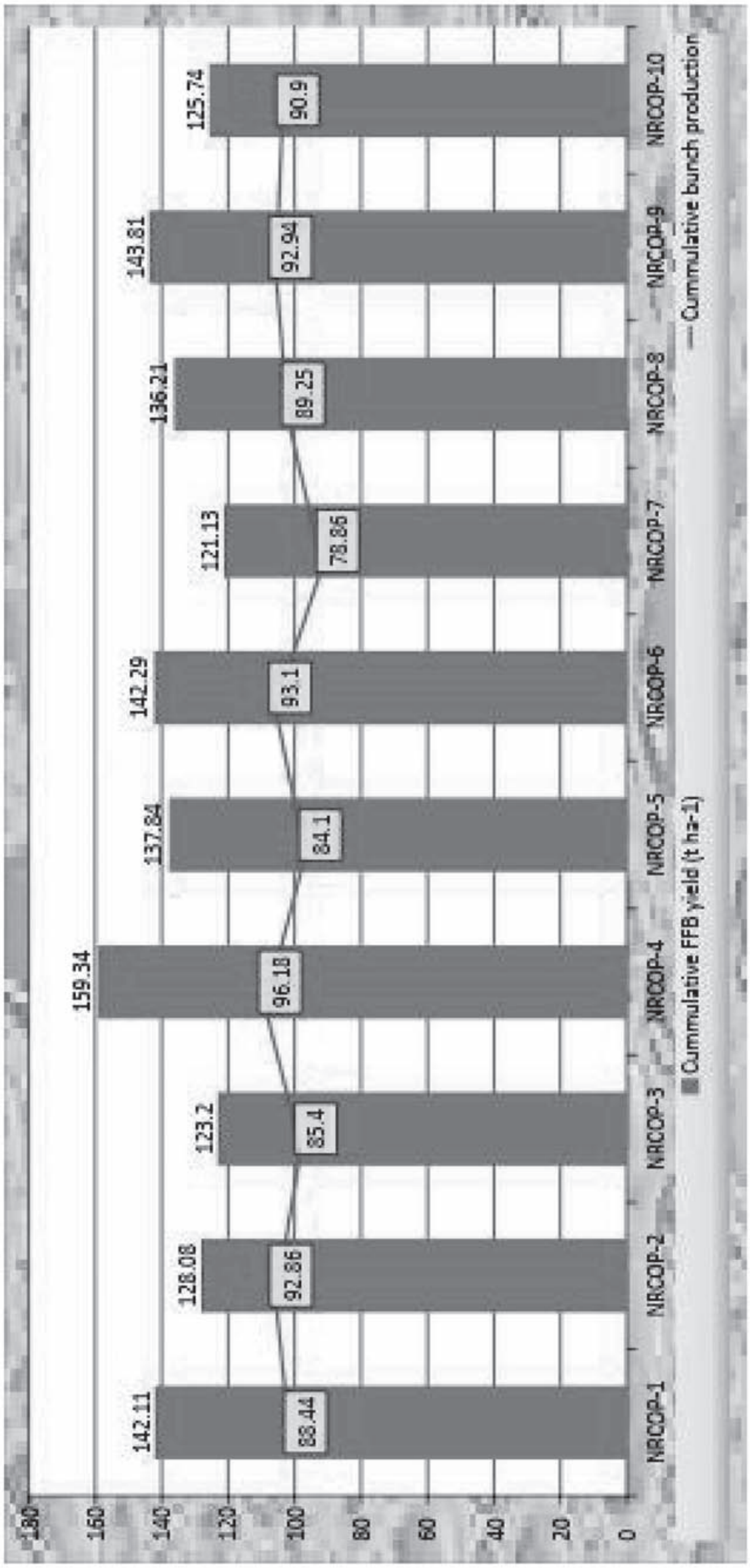

Fig. 3. Cumulative production potential of ten crosses in their 10 years production period

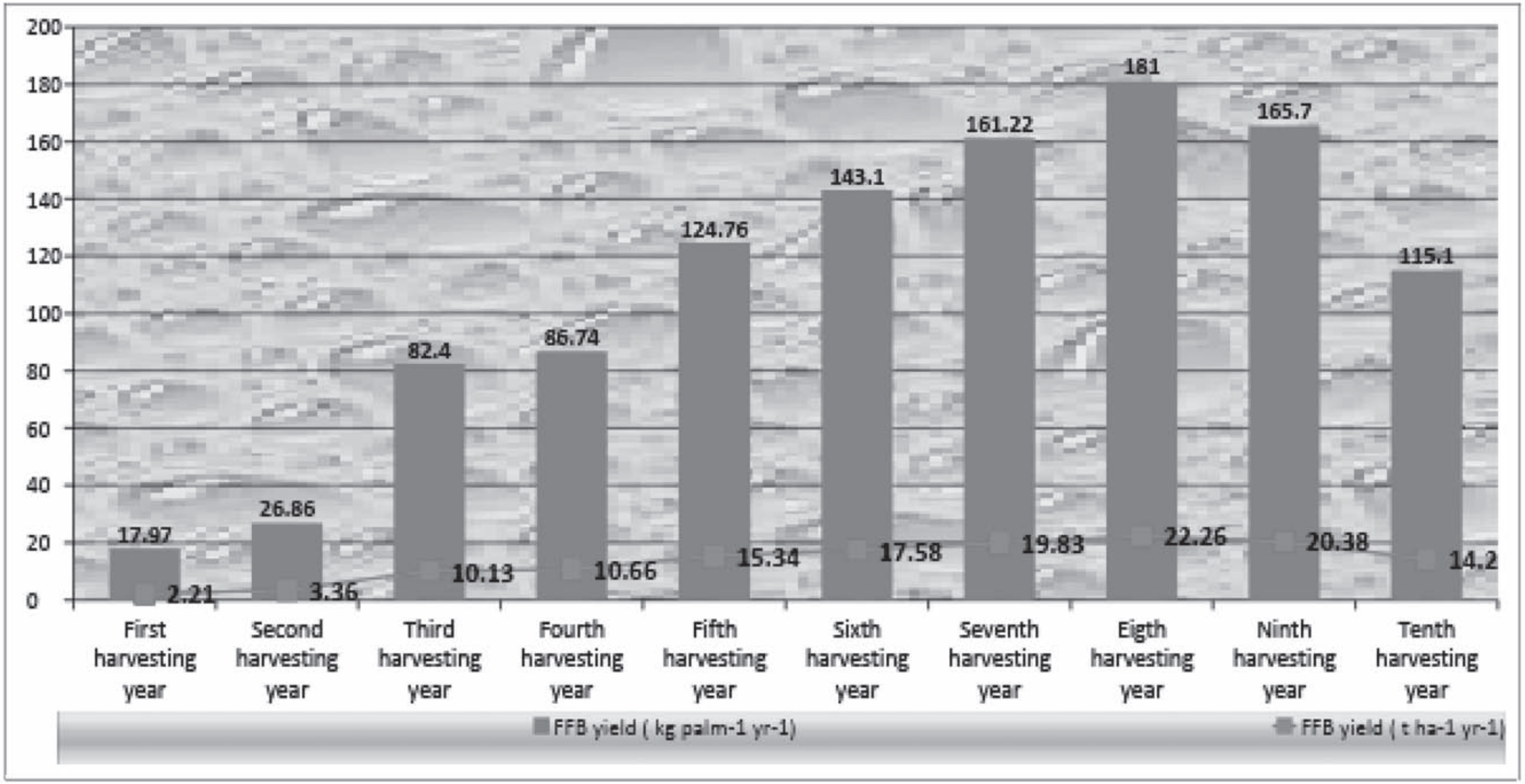

Fig. 4. Production trends in oil palm crosses in their 10 years production

CONCLUSION

In the first five harvest years, FFB production increased with increase of bunch production and average bunch weight at a higher rate, which can be considered as yield incremental period. Cross combination NRCOP-4 was emerged as a most promising yielder among the ten crosses.

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IMPACT OF WEATHER PARAMETERS ON THE INCIDENCE OF WHITEFLY POPULATION IN DIFFERENT POTATO (*Solanum tuberosum* L.) CULTIVARS

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ABSTRACT

Potato cultivars (13 no.) were assessed for the incidence of whitefly, *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) during *Rabi* seasons from 2015-2016 to 2017-2018. Initial whitefly population is observed in the crop during3rd week of December (51st to 52nd meteorological standard week) with the peak at 3rd to 4th week of February (7th to 8th MSW). However, the level of whitefly population was varied among the potato cultivars. In all the cultivars, the whitefly population declined gradually after the peak, however, over the duration the attainment of a higher population differed among the cultivars. A significant and positive correlation of whitefly population was recorded with maximum and minimum temperature and bright sunshine hours, whereas, maximum and minimum relative humidity had a negative correlation. It was evident from the step-wise multiple regression analysis that maximum temperature had a significant influence on the fluctuation of whitefly population. Besides, collective influence (41.1% to 66.5%) of all the weather parameters on the whitefly population was also recorded (from adjusted R^2 value 0.411 to 0.665) in different potatocultivars.

Keywords: Potato cultivars, Whitefly incidence, Population fluctuation, Weather parameters, Correlation,Regression

INTRODUCTION

Potato (*Solanum tuberosum* L.) plays a vital role like other essential vegetables in our daily diet. All over the country potato is grown under a wide range of agro-climatic conditions and secures 3rd and 4th rank in the world in the area (2.16 m ha) and production (53.04 mt), respectively, with the productivity of 24.56 t ha^{-1} (GoI, 2019). Pest and disease infestations along with varietal limitations are the major constraints for achieving higher potato production. All over the world nearly 100 insect and non-insect pests were recorded to infest potato crop and of which whitefly, *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) is one of the most important sucking pest that can cause damage by sucking the plant sap and also transmitting various potato viruses (Konar and Paul, 2005; Dharpure, 2002). A detailed study on the incidence pattern of whitefly against different tolerant or resistant potato cultivars and the effect of prevailing physical ecological parameters on the fluctuation of whitefly population is currently needed (Chandramohan and Nanjan, 1992) as they have

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a greater impact on the development, survival and population build-up of the pests (Shera *et al.,* 2013). The knowledge in this field ultimately helps to develop effective management strategies against the whitefly incidence on potato and to fulfill the objective of the study in this platform of research.

MATERIAL AND METHODS

The investigation was conducted for three consecutive years during *Rabi* seasons of 2015-16, 2016-17 and 2017-18 at District Seed Farm (23.2° N latitude 87.8° E longitude and 30 m above mean sea level) of the State Department of Agriculture, Burdwan, West Bengal. Potato cultivars 13 no. *viz.,*T_1=Kufri Shailaja, T_2=Kufri Khyati, T_3=Kufri Sadabahar, T_4=Kufri Jyoti, T_5=Kufri Himalini, T_6= Kufri Pukhraj, T_7=Kufri Chipsona-3, T_8=Kufri Surya, T_9=Kufri Ashoka, T_{10}=Kufri Lalima, T_{11}=Kufri Chipsona 2, T_{12}=Kufri Chandramukhi and T_{13}=Kufri Atlantic were laid out in randomized block design (RBD) and replicated thrice. Each plot size was 3×4 sq.m where potato seeds were sown by 60x20 cm spacing. Standard agronomic practices were followed except for pesticides application. The crop was dehaulmed 2nd week of March in all the plots. The incidence of whitefly in different potato cultivars was recorded weekly starting from three weeks after sowing up todehaulmingof the crop by following 100-leaf index method (Simpson, 1940) with slight modification like the data on whitefly populations was recorded on 30 compound leaves each from the upper, middle, and lower canopy of 10 randomly selected plants from each plot. The mean population of whitefly was obtained from different potato cultivars were subjected to simple correlation and multiple regression analyses (Gomez and Gomez, 1984) by using SPSS software (version 16.0) with different meteorological parameters like maximum and minimum temperatures (°C), maximum and minimum humidity (%), rainfall (mm) and bright sunshine (h), obtained from the Department of Agro-Meteorology, Burdwan.

RESULTS AND DISCUSSION

Seasonal incidence ofwhitefly

Three years pooled data revealed that initiation of whitefly infestation in the crop was initiatedduring 51st to 52nd MSW in December and remained active throughout the crop-growing season at varying population density among different potato cultivars (Fig. 1). The peak population varied from 13.3 to 56.4 whitefly/30 compound leaves during the vegetative growth stage of the crop at 7th to 8th MSW (Table 1) after which the pest population decreased gradually in all the cultivars (Fig. 1). Results (Table 1) also revealed that whitefly population remained at a higher level in major potato cultivars before dehaulming at 9 MSW and the level of whitefly population range was also varied markedly throughout the crop growing seasons. Higher population of whitefly persisted for a longer period in some cultivars. The cultivars Kufri Atlantic, Kufri Ashoka, Kufri Lalima, Kufri Jyoti, Kufri Chipsona-2, and Kufri Himalini showed the higher pest population, whereas, Kufri Khyati, Kufri Surya, Kufri Chandramukhi, Kufri Shailaja, and Kufri Sadabahar sustained a moderate level of the pest infestation. The whitefly incidence was recorded minimum in Kufri Pukhraj and Kufri Chipsona-3 which might be due to the morphological characters such as rough, narrow, coarse and smaller leaves than the other cultivars (Paul and Konar, 2006). It was also recorded that bottom leaves of the most of the

Table 1. Population dynamics of whitefly during the potato crop growing seasons (Three years pooled data, 2015-18)

Parameters	No. of whitefly/30 compound leaves												
	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13
Initial population	1.4 (51)	0.9 (52)	2.4 (51)	3.4 (51)	2.4 (51)	0.9 (52)	0.6 (52)	0.3 (51)	8.7 (51)	8.4 (51)	4.4 (51)	0.9 (52)	6.4 (51)
Peak Population	22.7 (8)	19.1 (7)	27.1 (8)	38.7 (8)	42.3 (8)	13.3 (7)	13.7 (7)	20.0 (8)	55.1 (8)	56.4 (8)	48.5 (8)	16.0 (7)	49.3 (8)
Terminal population	8.4 (9)	5.3 (9)	8.9 (9)	13.3 (9)	16.0 (9)	2.7 (9)	3.5 (9)	6.3 (9)	26.7 (9)	26.7 (9)	20.9 (9)	4.5 (9)	21.3 (9)
Population Range	1.4-22.7	0.9-19.1	2.4-27.1	3.4-38.7	2.4-42.3	0.9-13.3	0.6-13.7	0.3-20.0	8.7-55.1	8.4-56.4	4.4-48.5	0.9-16.0	6.4-49.3
Attainment of max. population	8.5-22.7 (5-8)	8.9-13.3 (5-8)	11.1-27.1 (5-8)	13.1-13.3 (5-9)	12.0-16.0 (5-9)	8.0-9.3 (6-8)	9.3-11.5 (6-8)	11.1-20.0 (6-8)	15.0-26.7 (52-9)	12.0-26.7 (52-9)	10.7-20.9 (3-9)	12.9-15.1 (6-8)	12.0-21.3 (52-9)

T1: K. Shailaja; T2: K. Khyati; T3: K. Sadabahar; T4: K. Jyoti; T5: K. Himalini; T6: K. Pukhraj; T7: K. Chipsona-3; T8: K. Surya; T9: K. Ashoka; T10: K. Lalima; T11: K Chipsona-2; T12: K. Chandramukhi; T13: K. Atlantic; *Data in parentheses indicate meteorological standard week

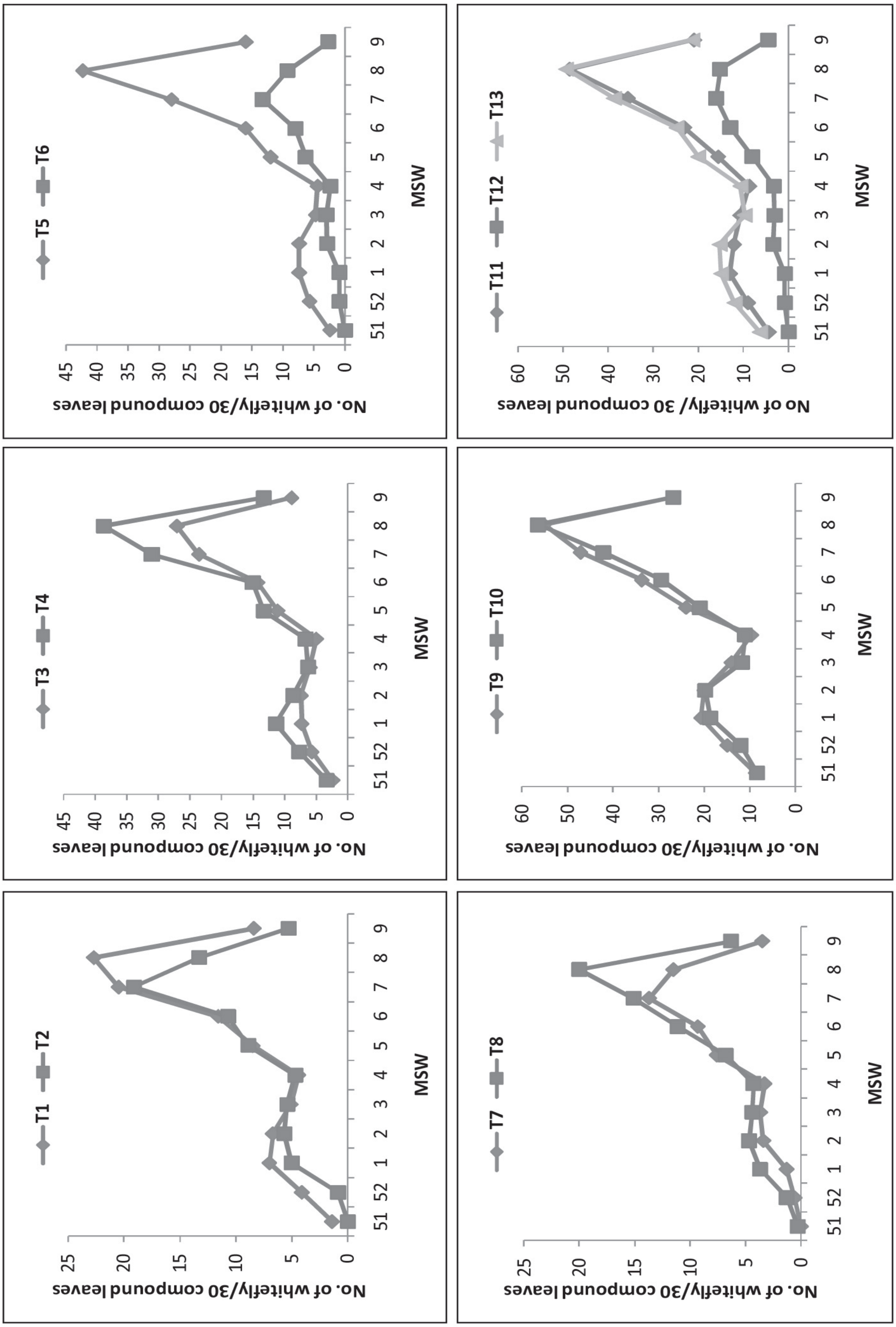

Fig. 1.Population fluctuation of whitefly in different cultivars of potato (T_1 to T_{13}) during the different meteorological standard weeks (MSW) of crop growing seasons

potato cultivars maintained the higher whitefly population,unlike upper leaves, suggesting whiteflymight have better preference for senescing leaves under shady conditions. It was also reported that Kufri Chandramukhi was susceptible to whitefly (Konar and Singh, 2009). On the contrary, Kufri Chipsona-1 and Kufri Chipsona-2 proved resistant, however, both Kufri Jyoti and Kufri Jawhar were tolerant to the pest.

Impact of weather parameters

Correlation analysis between whitefly population and weather parameters showed that the insect population was not influenced by a single weather parameter, rather more than one parameter was responsible for building-up of whitefly population during the crop growing seasons. Furthermore, the taller height of the plants of the cultivars might pose an unfavorable microclimatic condition within the crop canopy as the whitefly population was recorded negatively correlated with the relative humidity and positively correlated with temperature during *Rabi*season (Kishore *et al.,* 2005 and Bhatnagar *et al.*, 2012). Whitefly population was positively correlated with maximum (T_{max}) and minimum temperature (T_{min}), temperature gradient, and bright sunshine hours (BSS). T_{max} andT_{min} had a significant effect on the fluctuation of pest population. Whereas, in all the cultivars both maximum and minimum relative humidity showed a negative correlation (Table 2). Lanunocheta and Pankaj (2012) reported the same that whiteflypopulation on potato was positively correlated with temperature, sunshine hours and rainfall, but negatively correlated with relative humidity. The findings are in conformity with Paul and Konar (2003) who reported that the abiotic factors *viz.,* maximum and minimum temperature, maximum and minimum relative humidity and bright sunshine hour had significant effect on whitefly population.

The understanding of the different weather parameters affecting the population of the insect pest is a prerequisite for proper planning of an effective and more precise management strategy for a particular pest. A recent trend in this research field is to develop innovative models and procedures for identifying the key factors predominating the distribution and abundance of insect pests. Development of weather-based models of population phenology can enrich the knowledge for decision-making processes around pest control and provide better opportunity to control the pest within integrated pest management modules (Damos and Soultani, 2010). Hence, the cumulative effect of the weather parameters was analysed by multiple regression for consecutive three years (2015-16, 2016-17, and 2017-18) and pooled (Table 3). The regression model (predicted regression equation) revealed a comprehensive picture of the relationship between whitefly population and weather parameters. Step-wise regression analysis was done to drop the least significant factors in a stepwise manner and finally to workout the best effective prediction model. In the prediction model (regression equation) most of the weather parameters were excluded except the maximum temperature. This findings revealed that maximum temperature played the most significant role in the population fluctuation of the whitefly. Output of the regression equations were adjudged by the significance test of the coefficient of determination (R^2) and the parameter was further adjusted to calculate the more precise value by using Adjusted R^2 which

Table 2. Correlation coefficients between abiotic factors and whitefly population in different potato cultivars (Three years Pooled data)

Weather parameters	Potato cultivars												
	T1	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**	**T9**	**T10**	**T11**	**T12**	**T13**
T_{max} (p C)	0.63*	0.61*	0.63*	0.64*	0.71*	0.56*	0.52*	0.65*	0.74**	0.73**	0.72**	0.58*	0.71**
T_{min} (p C)	0.61*	0.59*	0.63*	0.65*	0.73*	0.55*	0.45	0.63*	0.72**	0.72**	0.70**	0.53*	0.70**
$T_{gradient}$ (p C)	0.33	0.35	0.28	0.24	0.28	0.31	0.39	0.35	0.37	0.35	0.36	0.39	0.34
RH_{max} (%)	-0.22	-0.22	-0.19	-0.14	-0.27	-0.23	-0.17	-0.30	-0.29	-0.29	-0.30	-0.27	-0.30
RH_{min} (%)	0.03	-0.04	0.07	0.03	-0.01	-0.03	0.28	-0.08	0.29	-0.06	-0.03	-0.04	-0.08
BSS (h)	0.47	0.44	0.46	0.42	0.47	0.52*	0.44	0.55*	0.46	0.48	0.51*	0.56*	0.54*
Rain (mm)	0.35	0.44	0.31	0.21	0.17	0.31	0.30	0.17	0.35	0.28	0.22	0.22	0.23

T_1: K. Shailaja; T_2: K. Khyati; T_3: K. Sadabahar; T_4: K. Jyoti; T_5: K. Himalini; T_6: K. Pukhraj; T_7: K. Chipsona-3; T_8: K. Surya; T_9: K. Ashoka; T_{10}: K. Lalima; T_{11}: K Chipsona-2; T_{12}: K. Chandramukhi; T_{13}: K. Atlantic; *Significant at 5% level; **Significant at 1% level

Table 3. Step-wise multiple regression analyses of ecological parameters vs whitefly population in different potato cultivars during the crop growing seasons (Three years pooled data)

Potato cultivars	Prediction equation	Adjusted R^2	Significant for Standardized coefficients
T_1	$Y = -10.594+1.413\ X_1$	0.554*	p=0.005
T_2	$Y = -12.185+0.752\ X_1$	0.560*	p=0.002
T_3	$Y = -12.212+1.648\ X_1$	0.550*	p=0.005
T_4	$Y = -18.800+2.361\ X_1$	0.590*	p=0.003
T_5	$Y = -25.033+2.746\ X_1$	0.665*	p=0.001
T_6	$Y = -10.438+0.580\ X_1$	0.411*	p=0.002
T_7	$Y = -11.620+0.665X_1$	0.444*	p=0.001
T_8	$Y = -16.062+0.899X_1$	0.498*	p=0.005
T_9	$Y = -21.887+3.357X_1$	0.652*	p=0.002
T_{10}	$Y = -22.592+3.291X_1$	0.645*	p=0.002
T_{11}	$Y = -22.630+2.934X_1$	0.637*	p=0.002
T_{12}	$Y = -16.707+0.889X_1$	0.507*	p=0.005
T_{13}	$Y = -20.222+2.902X_1$	0.631*	p=0.002

T_1: K. Shailaja; T_2: K. Khyati; T_3: K. Sadabahar; T_4: K. Jyoti; T_5: K. Himalini; T_6: K. Pukhraj; T_7: K. Chipsona-3; T_8: K. Surya; T_9: K. Ashoka; T_{10}: K. Lalima; T_{11}: K Chipsona-2; T_{12}: K. Chandramukhi; T_{13}: K.Atlantic

Y: Whitefly population (Dependent variable); X_1=Max.Temp. (°C), X_2=Min. Temp. (°C), X_3 =Temp. Gradient,X_4= Max. Humidity (%), X_5= Min. Humidity (%), X_6= Sunshine (h), X_7= Rainfall (mm)

Excluded variables:X_2, X_3,X_4, X_5, X_6, X_7; * Significant at 5% level (p=0.05)

reflected the combined effect of all the weather parameters on the abundance of whitefly populationin the crop field during the crop growing seasons. The adjusted R^2 values among the different potato cultivars were varied from 0.411 to 0.665 which reflected the combined effect of all the weather parameters on the fluctuation of whitefly population was ranging between 41.1 to 66.5% and proved significant at p = 0.05.

CONCLUSION

The infestation of whitefly on potato crop showed fluctuations occurring to weather variations over the study period. The establishment of significant and positive correlations of whitefly population with temperature and bright sunshine hours exerted that when the temperature rose during February, the infestation increased gradually. These findings revealed that increasing temperatures and bright sunshine hours created a suitable condition that favored the building-up the population of whitefly. This information will help in formulating a better prediction model by which the outbreak of this pest could be known in advance and timely control measures can be taken up to curtail the problem. Furthermore, the overall response of weather parameters on fluctuation of pest population is dependent on the impact of climate change, host plant characters and some other factors. Multiple regression analysis showed that measured weather parameters have a significant effect on the insect pest densities (P = 0.05) confirming the results of correlation analysis. Varying level of whitefly population throughout the crop growing seasons might be due to the varying influence of prevailing weather parameters. After validation of individual seasonal data, these types of information might be useful to formulate a better forecasting model and thereby developing effective management strategy for this pest.

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CORRELATION AND PATH ANALYSIS OF TOMATO CROP (*Solanum lycopersicum* L.) UNDER PROTECTED CONDITIONS

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ABSTRACT

Tomato genotypes (40 no.) were studied for eight quantitative characters from October 2014 to April 2015 to assess the nature and magnitude of genetic variability under protected conditions. A wide range of variation was noticed among the characters studied.The genotypic correlation coefficients were similar in nature and higher in magnitude than the corresponding phenotypic correlation coefficients. Yield recorded positive correlation with fruits per plant (0.6224), truss per plant (0.7809), fruits per truss (0.6720) and fruit weight (0.6360). Path analysis revealed considerable positive indirect effects on yield per plant as exerted by fruits per plant, truss per plant, fruit length, fruit weight and fruit girth. Highest positive direct effect was recorded for fruit weight (0.3956) followed by truss per plant (0.3558) and fruits per plant (0.3381). This indicates the importance of these characters in yield improvement programme in tomato under protected conditions.

Keywords: Tomato, protected cultivation, yield, correlation, path analysis

INTRODUCTION

Vegetable production is significantly influenced by the seasonality and weather conditions. Vegetable cultivation in partially or fully protected environments are bound to pay rich dividends to the farmers as they are high value and high quality commodities. Protected cultivation aims to achieve independence of climate and weather and to allow crop production in areas where the natural environment limits or prohibits plant growth. In this present scenario of perpetual demand of vegetables and drastically shrinking land holdings in the country, it is the best alternative and drudgery less method for using resources more efficiently. India being a vast country with diverse and extreme agro-climatic conditions, the protected vegetable cultivation technology can be utilized for the year round as well as off-season production of high value, low volume vegetables, production of virus free quality seedlings, hybrid seed production and for disease resistance breeding programs (Wani *et al.,* 2011). Tomato, (*Solanum lycopersicum* L.) is being extensively cultivated under protected conditions and gives higher returns. The crop productivity is influenced by the genetic characteristics of the cultivar, growing environment and management practices. The

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knowledge of nature and magnitude of association between yield and its component traits is very important for effective selection in advance generations. The study of correlation between various quantitative traits provides an idea of association that could be successfully exploited to formulate selection strategy for improving yield components in crops. The relative magnitude of association of various characters with yield has to be considered for an effective selection programme. The path coefficient technique helps in assessing the direct and indirect contribution of various traits out of the total correlation towards yield. The study aimed to analyse the quantum importance of individual characters to accelerate the selection programme for better gains in tomato under protected conditions of Kerala.

MATERIAL AND METHODS

The experimental material in the study consisted of 40 tomato genotypes collected from various sources. The experiment was laid out in randomized block design (RBD) with 40 treatments replicated thrice at College of Agriculture, Vellayani, Kerala during October 2014 to April, 2015. The study was conducted in saw tooth type naturally ventilated polyhouse of gutter height of five meter height, gutter slope of two percent and size 1000 m^2 (50 m x 20 m) located at Instructional Farm, Vellayani. Seedlings were raised in protrays and transplanting was done at a spacing of 75 x 60 cm in raised beds. Beds were covered with silver on black plastic mulch of 30 μ thickness. Drip system of irrigation was followed under polyhouse condition. NPK fertilizers were applied as per the schedule for precision farming in tomato. Plants were supported with stakes and trained to grow vertically upwards along a polythene twine which is tied at gutter height of 3m. Periodic pruning of the tomato plants facilitated easy training operation and also permitted closer planting, early ripening of fruits and get higher yields of larger sized fruits.

The analysis of variance was completed according to the procedure suggested by Panse and Sukhatme (1967) for each of the characters separately. Phenotypic and genotypic correlation coefficients were assessed as per the procedure suggested by Singh and Choudhary (1985). The direct and indirect effects of the yield contributing factors were estimated through path analysis (Wright, 1921 and Dewey and Lu, 1959).

RESULTS AND DISCUSSION

In the study, correlations between eight traits were worked out in all possible combinations at both phenotypic and genotypic levels (Table 1). In general, the magnitude of genotypic correlation coefficients were greater than the corresponding values of the phenotypic correlation coefficients. This is an indication of strong genetic association between these traits. Similar result was observed by Rahman *et al.* (2015) in a study where forty-eight genotypes of tomato were assessed for yield contributing characters to observe their associations and direct and indirect effect onyield.This study also recorded that both genotypic and phenotypic correlations were similar in direction.

Fruits per plant had a significant positive association with truss per plant, fruits per truss and yield per plant. Truss per plant had positive correlation with fruits per truss, fruit length, fruit girth and fruit weight. Positive and significant association was noticed between fruits per truss and fruit length, fruit weight, fruit girth and yield per plant. Significant phenotypic and genotypic correlation was noticed between fruit length, fruit weight and fruit girth. Fruit weight had significant positive association with fruit girth as reported by Hidayatullah *et al.* (2008) in tomato.

Yield per plant recorded positive correlation with fruits per plant (0.6224), truss per plant (0.7809), fruits per truss (0.6720), fruit length (0.4522), fruit weight (0.6360) and fruit girth (0.4770). These results are in agreement with the findings of Madhurima and Paul (2012) and Patel *et al*. (2013). Thus, it can be stated that selection for fruits per plant, fruits per truss, fruit length, fruit girth and fruit weight would be helpful for yield improvement of tomato under polyhouse conditions. Emphasis for selection of these traits in desired direction for crop improvement in tomato had also been suggested by earlier workers (Narolia *et al.*, 2012; Kumar *et al*., 2013).

Correlation coefficients reveal only the relation between yield as well as yield components and not the actual direct and indirect effects of the components on yield. Path analysis helps in partitioning the genotypic correlation coefficient into direct and indirect effects of the component characters on yield on the basis of which crop improvement programmes can be planned effectively. The differential emphasis is to be given based on the degree of direct and indirect influence of the component characters on the economic character of interest as revealed by path coefficient analysis. If the correlation between yield and any of its components is due to the direct effect, it reflects a true relation between them and selection can be practiced for such character in order to improve yield. However, if the correlation is mainly due to indirect effect of the character *via* another component trait, the breeder has to select the latter trait through which the indirect effect is exerted.

In this study, under poly house environment, path analysis was used to separate the genotypic correlation coefficients of yield per plant with seven characters *viz.,* plant height, truss per plant, fruit length, fruit girth, fruit weight,fruits per truss and fruits per plant (Table 2). All characters except plant height and fruits per truss recorded positive direct effect on yield. Highest positive direct effect was observed for fruit weight (0.3956) followed by truss per plant (0.3558), fruits per plant (0.3381), fruit girth (0.1428) and fruit length (0.0304). This trend indicates the importance of these characters in yield improvement programme under protected conditions. The indirect effect of fruits per truss *via* all other characters was positive and similar to its positive genotypic correlation with yield. Plant height had a negative direct effect with yield and negative indirect effect with truss per plant and fruits per plant. This could be possibly due to the wide variation of plant height among the 40 genotypes under study. Eventhough some genotypes did not gain much height they had more secondary branches thereby higher number of truss per plant and fruits per plant resulting in a higher yield compared to the taller genotypes. These findings are in consonance with the reports of Rani *et al*. (2008); Ara *et al*. (2009) and Monamodi *et al*. (2013), with respect to fruit weight where fruit weight exerted high direct positive effecton yield. Joshi *et al.* (2004), Ghosh *et al*.(2010) and Monamodi *et al*. (2013)reported that fruits per plant showed high positive direct effect on fruit yield perplant as

Table 1. Genotypic and phenotypic correlation coefficients

Character	Correla tion	Plant height	Fruits per plant	Truss per plant	Fruits per truss	Fruit length	Fruit weight	Fruit girth	Yield per plant
Plant height	G	**1.0000**	-0.2554	-0.1281	-0.4217	0.2987	0.1461	0.0006	-0.0836
	P	**1.0000**	-0.2407	-0.1283	-0.3964	0.2814	0.1355	-0.0206	-0.0766
Fruits per Plant	G		**1.0000**	0.7734	0.6566	0.0058	0.0531	-0.0683	0.6224
	P		**1.0000**	0.7528	0.6361	0.0024	0.0485	-0.0513	0.6185
Truss per plant	G			**1.0000**	0.7707	0.1265	0.3272	0.2602	0.7809
	P			**1.0000**	0.7501	0.1105	0.3245	0.2511	0.7687
Fruits per truss	G				**1.0000**	0.3044	0.3260	0.2821	0.6720
	P				**1.0000**	0.2686	0.3219	0.2630	0.6557
Fruit length	G					**1.0000**	0.7662	0.5798	0.4522
	P					**1.0000**	0.7078	0.5109	0.4343
Fruit weight	G						**1.0000**	0.6337	0.6360
	P						**1.0000**	0.5944	0.6211
Fruit girth	G							**1.0000**	0.4770
	P							**1.0000**	0.4501
Yield per plant	G								**1.0000**
	P								**1.0000**

Table 2. Direct and indirect effect of yield components of tomato

Character	Plant height	Fruits per plant	Truss per plant	Fruits per truss	Fruits length	Fruits weight	Fruit girth
Plant height	**-0.0241**	0.0061	0.0031	0.0102	-0.0072	-0.0035	0.0000
Fruits per plant	-0.0864	**0.3381**	0.2615	0.2220	0.0020	0.0180	-0.0231
Truss per plant	-0.0456	0.2752	**0.3558**	0.2742	0.0450	0.1164	0.0926
Fruits per truss	0.0054	-0.0085	-0.0099	**-0.0129**	-0.0039	-0.0042	-0.0036
Fruit length	0.0091	0.0002	0.0038	0.0093	**0.0304**	0.0233	0.0176
Fruit weight	0.0578	0.0210	0.1294	0.1289	0.3031	**0.3956**	0.2507
Fruit girth	0.0001	-0.0098	0.0372	0.0403	0.0828	0.0905	**0.1428**
Genotypic correlation with yield	**-0.0836**	**0.6224**	**0.7809**	**0.6720**	**0.4522**	**0.6360**	**0.4770**

observed in this study. The path coefficient analysis revealed that fruit weight, truss per plant and fruits per plant are potential selection criteria for improving tomato fruit yield.

CONCLUSION

The study revealed that fruit yield per plant had highly significant and positive association with fruits per plant, truss per plant, fruit length, fruit weight and fruit girth. Hence, these characters can be identified as major characters contributing towards yield directly and indirectlyand selection might be effective in developing high yielding tomato varieties suited for protected cultivation.

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PERCEPTION OF UNDERGRADUATE STUDENTS OF S.V. AGRICULTURAL COLLEGE REGARDING ONLINE CLASSES DURING THE COVID-19 PANDEMIC

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ABSTRACT

The online survey was conducted between June, 2020 and August, 2020 to understand the perception of the undergraduate students of the S.V. Agricultural College, Tirupati regarding online classes. Out of 300 undergraduate students pursuing 1st, 2nd, and 3rd year of B.Sc (Hons.), 72 students belonging to all three years responded. The perception of the students was categorised under four aspects *viz.,* perception of learning environment, social perception, academic self-perception and perception of students on faculty members.The majority of the students (97.1%) were using smartphone for attending virtual classes, ranked online lecture supported by a screen shared PowerPoint as the best virtual teaching method with a weightage of 278 and 3 hrs/day was the comfortable screen time mentioned by 50 percent of the students. About 95.7 percent of the students perceived that a real class environment helps in good understanding than an online learning environment. The majority (87.2%) stated that learning in isolation is not exciting.Less than half (44.10 %) of respondents expressed satisfaction, while 55.90% of the respondents expressed dissatisfaction towards virtual classes.

INTRODUCTION

The outbreak of pandemic Covid-19 all over the world has seriously affected various sectors across the globe shrinking the global economy to unexpected low levels. Disturbance is seen in all walks of life *i.e.,*political, agricultural, retail, aviation, tourism, social, economic, religious, financial structures and education system is no exception.Most governments around the world have temporarily closed educational institutions in an attempt to contain the spread of COVID-19. As of 7 June 2020, approximately 1.725 billion learners were affected as a result of school closures in response to the lockdown due to pandemic. According to the UNICEF (2020), 134 countries implemented nationwide closures and 38 implemented local closures, which impacted about 98.5 percent of the world's student population. Schools in 39 countries are currently open (UNICEF accessed on 30th June 2020).

In an attempt to contain the spread of COVID-19 pandemic, in the second week of March 2020, the Government of India as well as

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the respective state governments had temporarily closed all educational institutions, from Kindergarten to Universities. As the days passed by with no immediate solution to stop the outbreak of Covid-19, Acharya N.G.Ranga Agricultural University, Guntur, Andhra Pradesh has closed its constituent colleges across the state. As a viable solution to fill in the void of classroom education (for a period of three to four months), the university has adopted online education while minimizing the chances of any infection to the students until classes resume. As this is the first time experience for the students attending online classes, an attempt has been made to understand the perception of the students about online teaching and learning environment and overall satisfaction regarding online classes.

MATERIAL AND METHODS

Acharya N.G. Ranga Agricultural University (ANGRAU), Andhra Pradesh had advised the faculty members of its constituent and affiliated Agricultural colleges to conduct online classes using the Zoom platform so that students do not miss the semester. Hence, S.V. Agricultural College, Tirupati, a constituent college of ANGRAU also started to conduct online classes for all undergraduate as well as post-graduate students as per the scheduled timetable. Since this is a new experience both to the teachers as well as the students, an online survey using Google docs was conducted to study the perceptions of the undergraduate students regarding online classes.

Out of 300 plus undergraduate students' pursuing 1st, 2nd, and 3rd year B.Sc (Hons) Agriculture at S.V. Agricultural College, Tirupati, 72 students belonging to all three years responded to the online survey which was conducted in the month of June-August, 2020. The survey was conducted through a well-structured online questionnaire using Google docs including questions on demographics, their perception regarding online classes and satisfaction towards the online classes. The responses received were compiled and analysed using frequency and percentage. The perception of the students was categorised into four different aspects: A**.** Perception of the learning environment;B. Social self-perception; C. Academic self-perception and D. Perception of students about faculty members.

RESULTS AND DISCUSSION

(i) Distribution of respondents according to their gender

Out of the total respondents, 31.9 per cent are male and 68.1 per cent are female students (Fig. 1). The strength of girl students opting for Agriculture sciences course is gradually increasing and it is clearly visible in the annual admissions every year.

(ii) Network connectivity available at the residence of the students

Majority of the students (59.4%) stated that 4G connectivity is available at their residence to attend the online classes, 31.9 per cent of the students stated that 3G/2G connectivity is available while 7.2 per cent of the students were using wi-fi connection and a meager 1.5 per cent stated that they do not have any network connectivity in their area (Fig.2). As the mobile phone technology and the mobile network connectivity has penetrated into rural India, most of the students were using 4G for attending online classes followed by 3G/2G network. Rural coverage of 4G data networks is not adequate of many service providers and Telecom operators are in the process of expanding their 4G network to meet growing demand in both rural and urban locations (Baburajan, 2018).

(iii) Device used to attend online classes

It is revealed from the Fig. 3 that about 97.1 per cent of the students used smart phone device to attend online classes, whereas, a meagre 2.9 per cent of the students are using Tablets/I-pads and Laptops to attend online classes. None of them used desktop computers to attend the online classes. As the cell phones along with smart features is available at an affordable rate in the market, majority of the respondents were using cell phones instead of purchasing other devices like I-pads or laptops or personal computers for attending online classes. India is the world's second largest telecommunications market and its total telephone subscriber base and tele-density reached 1,177.02 million and 87.45 per cent, respectively, as of January 2020 (Indian telecommunications Industry Report, June 2020). The results are in conformity with the report of Hindustan Times (2020).

n= 72

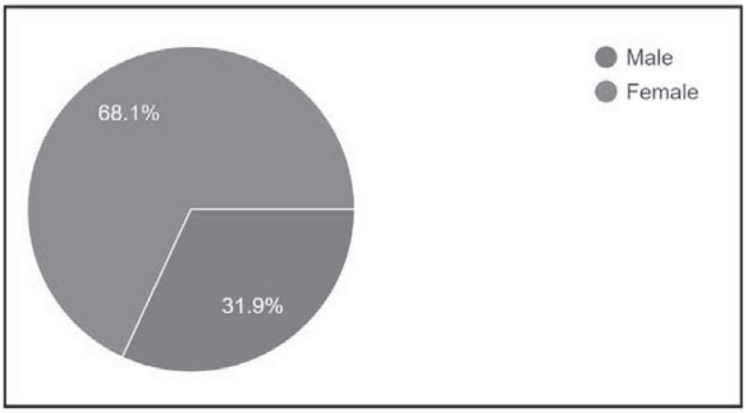

Fig.1.Distribution of the respondents according to their gender

n= 72

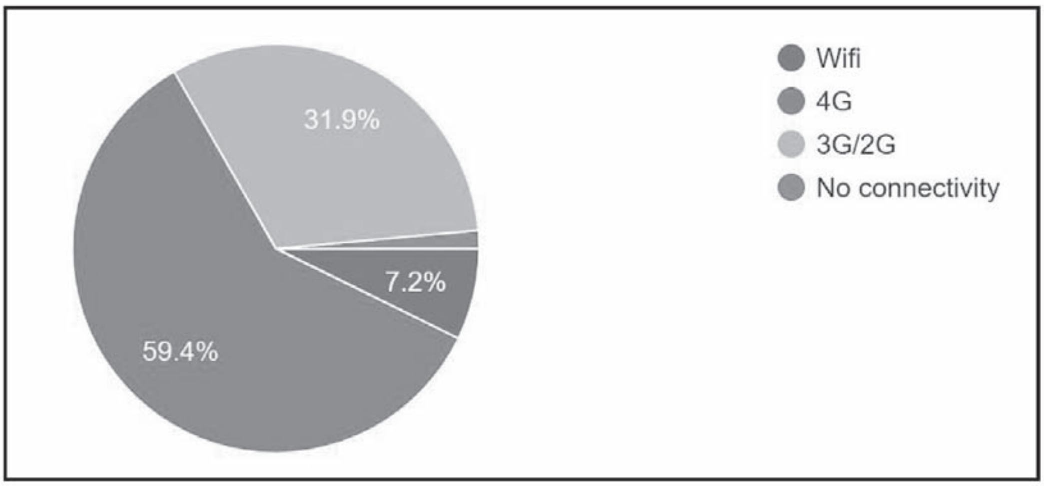

Fig.2.Network connectivity available at the residence of the students

n= 72

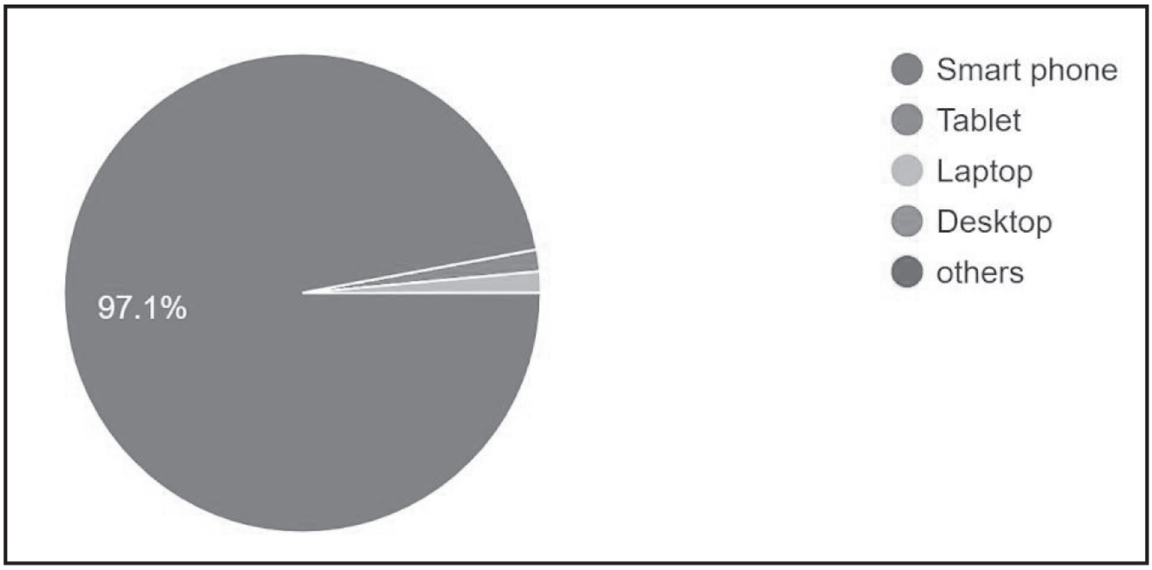

Fig. 3. Types of device/gadget used for attending online classes

(iv)Perception of the students on online learning environment

The perception of the students on different aspects of online learning environment is presented in Table 1.

A. Perception of the learning environment

Majority of the respondents reported better understanding of the lectures in real-time classroom environment than through online classes. The students stated that the enthusiasm, interest and excitement found in online classes are missing in the virtual classes resulting in passive learning. Majority opined that the quality of online instruction is not excellent and not an alternative to traditional class room teaching in the college.The intake of learning by a learner in learning is dependent on aptitude and motivation. It can be inferred that the students are not interested in virtual classes,however, are attending the online classes to avoid the loss of academic year.

B. Social self-perception

Regarding self-perception, it can be inferred that the students prefer learning while having interaction with teachers as well as their co-students. Face-to-face interaction is usually perceived as the best form of communication as compared to remote learning. Another challenge is that e-learning comes across as somewhat patchy and impersonal experience. Also, e-learning is likely to witness a high dropout rate due to lack of environment for studying. Students might tend to get distracted by gaming consoles, social media at home and might not feel a sense of community while taking online classes(*Deepali Kasrekar et al., 2020).*The results are in congruence with the statement given by Rohit Manglik (2020) that online learning appears to be no substitutes for field trips, academic exchanges and the social and cultural attractions of vibrant campus life.

C. Academic self-perception

It is understood that the students are more accustomed to the traditional chalk–talk teaching methods from their elementary education and this is their first experience of attending online classes for almost one semester. Hence it is difficult for them to adapt immediately to online platform. The confidence levels of the students are low and are not sure of gain in knowledge and achieve good score in the examinations and their learning outcome is affected.Hence, the impact of learning is uncertain and not always optimum.

D. Perception of students regarding faculty members competency for online teaching

About 40 per cent of the respondents disagreed that "Teachers need training for the conduct of online classes", whereas, 34.3 per cent were undecided and 25.7 per cent agreed. For the statement "Teachers are not competent enough to take online classes", 48.6 per cent disagreed, 34.3 percent undecided and 17.2 percent agreed. About 88.6per cent respondents disagreed, 8.6 percent undecided and 2.8 percent agreed to the item "Teachers didn't react to our queries / posts". All most all *i.e.,* 97.1 percent of respondents agreed that "there are network problems for both the teachers and students during conduct of online classes". For the statement "voice of some of the teachers is not suited for online classes", about 40 per cent of the students agreed, 31.4per cent undecided and 28.5 per cent disagreed. With regards to the item "clarifications with the teacher is not possible in online classes", 42.9 per cent agreed, 37.2 per cent disagreed while 20per cent undecided.

Online learning is a special kind of method and not all teachers are good at it or at least not all of them were ready for this sudden transition from face-to-face learning to online learning. (Kamlesh Misra, 2020). Thus, most of the teachers are just conducting lectures on video platforms such as Zoom which may not be real online learning in the absence of a dedicated online platform specifically designed for the purpose. There is a risk that in such a situation, learning outcomes may not be achieved and it may be resulting only in engaging the students. A teacher-student relationship can be best established in a classroom only.

Online learning offers a good substitute to classroom learning in time of emergency but it cannot replace the traditional classroom. Classroom learning still remains the main option as a subject can be taught through it and it is a better mode of imparting education and knowledge (Sanskriti Verma, 2020). The students are left with no option other than virtual learning due to the COVID 19 pandemic. The teachers are trying their best to teach the students online and have also asked them to contact whenever they face any difficulty in studying. Despite that classroom learning is better than remote learning and understanding concepts in the class is easier.

Table 1. Perception of the students regarding online classes taken during COVID crisis

n=72

S. No.	Item	% of students stating the degree of agreement		
		Agree	Undecided	Disagree
A.	**Perception of learning environment**			
1	Online learning environment helps me understanding more than real classroom environment	0	4.30%	95.70%
2	Online learning is more interesting	10.10%	14.50%	75.40%
3	Enthusiasm and excitement is missing in online class	82.60%	0	7.10%
4	Online learning is interactive and interesting	12.80%	11.40%	75.80%
5	Difficult to pay attention on classes continuously in online modules	88.80%	5.70%	5.70%
6	The quality of online instruction is excellent	22.90%	18.60%	58.50%
7	Online classes are being conducted at my own pace of understanding	31.40%	41.80%	26.90%
8	Understanding the concepts in online classes is difficult due to lack of practical exposure	91.40%	4.30%	4.10%
B.	**Social self-perception**			
9	Learning in isolation (without face to face interactions with friends and teachers) is not exciting	87.20%	7.10%	5.70%
10	Family members are disturbed due to online classes	38.60%	15.70%	45.70%
11	Student-to-student collaborations are valuable to me.	74.30%	22.90%	2.90%
12	Technical problems during online classes increases frustration and reduce interest on the lecture	95.70%	1.40%	2.80%
13	Online classes facilitates to do other important works also	47.20%	22.90%	30.00%

S. No.	Item	% of students stating the degree of agreement		
		Agree	Undecided	Disagree
14	Compared to face to face class, I am less motivated in an online class	80.00%	8.60%	11.40%
15	Online classes are unable to generate required attention	94.30%	2.90%	2.90%
16	Initially faced problem but now adapted to online classes	45.70%	24.30%	30.00%
C. Academic self-perception				
17	Knowledge gain is high in online classes compared to regular classroom lectures	4.30%	7.10%	88.60%
18	I learn best in online environment	7.20%	15.90%	76.80%
19	Online classes offer more flexibility in managing my study time	25.70%	17.10%	57.10%
20	I can get high grade in examinations with online classes compared to face to face classes	10.00%	14.30%	75.70%
21	Online classes are more flexible compared to face to face classes in classroom	7.10%	14.30%	78.60%
D. Perception regarding faculty members competency for online teaching				
22	Teachers need training for the conduct of online classes	25.70%	34.30%	40.00%
23	Teachers are not competent enough to take online classes	17.20%	34.30%	48.60%
24	Teachers didn't react to our queries / posts	2.80%	8.60%	88.60%
25	There are network problems for both the teachers and students for online classes	97.10%	1.40%	1.40%
26	Voice of some of the teachers is not suited for online classes	40.00%	31.40%	28.50%
27	Clarifications with the teacher is not possible in online classes	42.90%	20.00%	37.20%

(v) Ranking of online teaching methods

The students were asked to rank different online teaching methods as per their preference and their effectiveness based on their experience (Table 2). Based on the weighted score method, it is revealed from the table that first rank was given to the method “Oral Online lecture with the Power Point presentation screen”, second rank to the “Power Point presentation with narration”, third rank to “Oral Online lecture with the notes provided before the class”, fourth rank to “Recorded video of the lecture” and fifth rank to the method “Oral Online lecture”.

It can be inferred from the results that among different types of online teaching methods, majority of the students preferred online lecture supported by power point presentation screen as it creates enthusiasm and attention and reduces distractions.

Table 2. Ranking of online teaching methods by the students (n=72)

S.No	Online teaching method	Total weighted score	Rank
1	Online lecture orally with the Power Point presentation screen sharing	278	1
2	Power Point presentation with narration	269	2
3	Online lecture orally with the notes provided before the class	265	3
4	Online lecture orally with the use of White board	245	4
5	Recorded video of the lecture	238	5
6	Online lecture orally	210	6

(vi) Comfortable screen time (no. of hrs/ day) for attending the online classes

It is found that about 50 per cent of the students expressed that 2-3 hrs/day is the most comfortable screen time to attend online classes while 40% reported that 4-5 hrs/day is the comfortable screen time (Fig.4.). As per the suggestion of Union Ministry of Human Resources, GoI (July, 2020), the maximum screen time should be 3 hours per day for online classes for children. Prolonged screen time may cause digital eye strain resulting in headache, blurred or double vision, eye irritation, neck strain, backaches etc., for the learners. Moreover, the data usage and data balance per day at students end might have made them to feel that 4- 5 hrs per day of online classes is of optimum duration.

(vii) Overall satisfaction level of the respondents regarding the online classes experienced since lock down

More than half of the respondents of about 55.90% reported “not satisfactory”, 42.60% expressed “satisfactory” and a meagre 1.50% expressed “highly satisfactory” (Fig. 5). The results are in congruence with the study

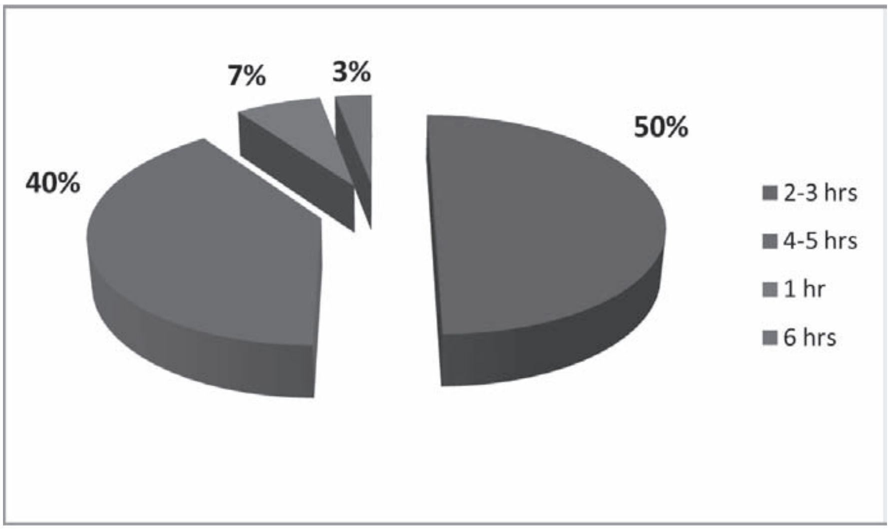

Fig.4. Comfortable screen time (no. of hrs/day) for attending the online classes

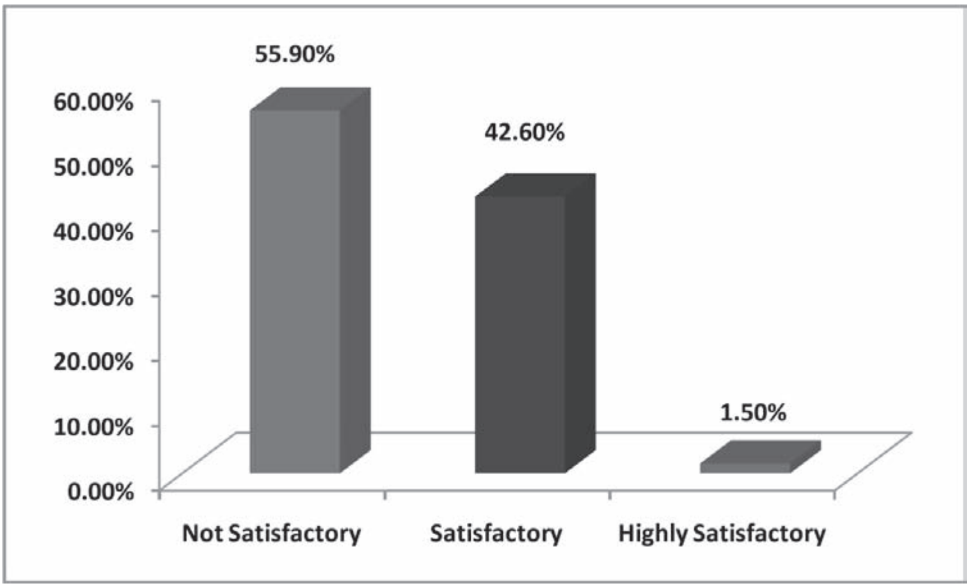

Fig.5.Overall satisfaction level of the students regarding the virtual classes

conducted by Virginia Roach and Linda Lemasters (2006) who recorded that students were more satisfied with the delivery of on-ground courses than the online courses.

CONCLUSION

Majority of the students (68.1%) are female, about 59.4 per cent were using 4G mobile data and 97.1 percent utilized mobile phone for attending the online classes. Regarding the perception of students on the learning environment, the majority of the students perceived that the traditional class room environment helps in better understanding of courses than the online environment,and excitement, interest, interaction and enthusiasm are missing in the online environment. The majority of the students perceived that it is difficult to pay attention to classes continuously in online mode and understanding the concepts in online classes is low due to lack of practical exposure. Regarding social self-perception, the students reported that learning in isolation is not exciting,as they are missing student-to-student collaborations. Moreover, technical problems such as network issues increase frustration. Furthermore, it is also inconvenient to the family members as their mobile phone device is borrowed for attending the online classes. The students reported that knowledge gaining is low in online classes compared to traditional class room environment, and, hence, getting good grades in examination is not possible with the online mode of learning. Regarding perception about faculty members competency for online teaching, majority expressed that teachers should also increase their competency for taking online classes. However, faculty members are quickly responding to the queries of the students. Because of sudden shift from the regular classroom environment to virtual environment, students, as well as teachers, were not prepared for the situation. As the pandemic Covid -19 is continuing, the teachers, as well as the students, should accept and continue the challenge of teaching and learning in blended method *i.e.,*both online and offline.

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PREVALENCE OF HEALTH PROBLEMS AMONG MENOPAUSAL WOMEN AND ASSESSMENT OF THEIR QUALITY OF LIFE: A COMMUNITY-BASED STUDY IN WESTERN ODISHA

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ABSTRACT

Menopause is a natural phenomenon in every of women's health. The descriptive cum exploratory research study was carried out in western Odisha among 330 rural, urban, and tribal women in the age group of 35-55 years, from April to September of 2018. Purposive sampling method was used to select the respondents. The findings of the study revealed that the mean menopausal age was 46.22±4.39 years. The most common symptoms reported by the women were irritability, physical and mental exhaustion (63%) and depression (56.96%). Hot flashes and night sweats were also found in 61.51% of the respondents, whereas, joint pain and muscular pains were found in 66.06% of women. Urogenital problems like bladder problems and dryness of the vagina were found among 59.39% and 35.45% respondents, respectively. However, a statistically significant association was found in the prevalence of menopausal symptoms and their degree of severity with menopausal status, and current age of menopausal women in this study which ultimately affects the quality of life of the menopausal women.

Keywords: Menopause, Menopausal symptoms, Quality of life, Urban, rural, tribal women, Odisha

INTRODUCTION

Menopause is a natural phase of women's health and every woman has to experience it in their later part of life (WHO). For some menopause is a pleasant experience while for others it may be problematic. It was observed by many researchers that most of the women experience the menopausal transition with difficulty along with significant stress. The presence and severity of symptoms vary from woman to woman and can last from months to years during this transitional period and has an impact on the daily life activities and quality of life at different stages of menopause. (Karmakar *et al.,* 2017). Place of residence, level of education, and social status also significantly affect the health status and quality of life of menopausal women. Because of facility, knowledge, and accessibility in the urban area, many health-related problems can be addressed effectively which is not possible in rural and tribal areas. However modern medicine increased the life expectancy of human being, ultimately woman has to spend one-third of her life in post-

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menopause periods. Thus, it is time to focus on health problems and quality of life of menopausal women through proper guidance, education, economic and social support. (Nisar *et al.,* 2009, Kawatkar *et al.,* 2015).

The purpose of this study is to assess the health problems and the quality of life of menopausal women residing in urban, rural, and tribal areas of Western Odisha by using the Menopause Rating Scale (MRS) (Heinemann, 2003).

MATERIAL AND METHODS

A descriptive cum exploratory study was carried out from April 2018 to September 2018 in purposively selected areas of Jharsuguda district, Western Odisha. Two blocks *i.e.* Jharsuguda and Kolabira were selected as the study area. A total of 330 women from urban, rural, and tribal areas (110 from each area) in the age group of 35 to 55 years were selected by the non-probability purposive sampling technique. A total of 110 urban respondents were selected from the municipality area of the Jharsuguda block. A total of 110 rural respondents and 110 tribal respondents were taken from Kolabira, Beherapat, Durlaga, Jamera, and Marakuta villages of the Jharsuguda district.

The information from the respondents was collected through interview schedule. For conducting the interview well-structured schedule was developed and the Menopause Rating Scale (MRS) developed by Heinemann (2003) was also included for data collection. The five-point rating scale (MRS) with 11 items was used which indicates the problems experienced by menopausal women in the past week and their rating depending upon the severity. The score increases point by point with increasing severity of subjectively perceived complaints in each of the 11 items (severity expressed in 0…4 point *i.e.* no symptoms, mild, moderate, severe, and very severe in each item). By checking the five possible boxes of severity for each of the items the respondents provided their perception. The total score of the MRS ranges between 0 (no symptoms) and 44 (highest degree of complaints). The scores vary between the three dimensions.

Psychological domain: 0 to 16 scoring points (4 symptoms: depressed, irritable, anxious, and exhausted); Somato-vegetative domain: 0 to 16 scoring points (4 symptoms: sweating/hot-flush, cardiac complaints, sleeping disorders, joint &muscle complaints); Urogenital domain: 0 to 12 scoring points (3 symptoms: sexual problems, urinary complaints, and vaginal dryness). The scores for each of the dimensions (sub-scale) are based on adding up the scores of the items of the respective dimensions. The total score is the sum of the dimension scores. For assessing the quality of life of the respondents, with reference to WHO standard of the severity of symptoms, the scores gained by the respondents by using MRS (Menopause rating scale) were (Total 44) summed up and they were classified as Good, Average and Poor according to their total score.

According to the severity of symptoms experienced by the respondents, their quality of life was judged. The quality of life is depicted as-No symptoms- Good quality of life; Mild symptoms- Average quality of life; Moderate symptoms- Fair quality of life; Severe to very severe symptoms- Low quality of life.

Table 1.Quality of life score with reference to WHO standard

S. No.	Quality of life	Total score	Percentage of score
1.	Good	0-2	0-4%
2.	Average	3-10	5-24%
3.	Fair	11-21	25-49%
4.	Poor	$\geq$22	>50%

RESULTS AND DISCUSSION

Demographic characteristics of the respondents

The study revealed that out of the total population, more than one-fourth (36.06%) of their respondents were laid between 35-40 years of age group compared to other age groups. Less than half of the women were found to be illiterate(28.48%). Nearly half of the women were housewives(49.69%) and (93.33%) of women were married and at the same time, the proportion of pre-menopausal women was found to be higher than post-menopausal women *i.e.* 36.06% and 35.15%, respectively. It is observed that most of the respondents had family income below Rs. 10,000 per month. The majority of respondents belonged to low socio-economic class (42.42%)whereas, 37.87% of respondents were in the higher socio-economic class. Small family size (up to 4 members) was found among 50% of the respondents in the study and 78% of participants belonged to nuclear families. Information on parity showed that 37.57% of the respondents had two children and 31.51% of the respondents had 3 to 4 children. Data on the lifestyle of the respondents depicts that 42.42% of women were heavy workers, whereas, 32.12% were sedentary. The majority (80%) women were having non-vegetarian food habits. It is interesting to note that 81.51% of the study samples had the habit of taking tea and 14.24% were chewing tobacco. Alcohol consumption was found only in 4.24% of the respondents.

Age at menopause

Table 2. Average menopausal age of the respondents (n=116)

Parameter	Age at menopause (years)				Average age at menopause
Range	<40	40-45	45-50	>50	46.22±4.39 Range 35-55 years
Number (%)	7(6.03)	40(34.48)	40(34.48)	29(25)	

Women who already attained menopause

Menopause symptoms

Table 3. Menopause symptoms experienced by the respondents (n=330)

Menopause Symptoms	No Symptoms	Severity of Symptoms					
		Mild	Mode-rate	Severe	Very Severe	Total	%
Psychological domain							
Depression	142 (43.03)	93 (28.18)	69 (20.9)	26 (7.87)		188	56.97
Anxiety	169 (51.21)	72 (21.81)	63 (19.09)	26 (7.87)		161	48.79
Irritability	98 (29.69)	85 (25.75)	65 (19.69)	59 (17.87)		209	63.33
Physical and mental exhaustion	119 (36.06)	84 (25.45)	82 (24.84)	45 (13.63)		211	63.94
Somato-vegitative domain							
Hot flashes, Night sweat,	155 (56.96)	56 (16.96)	67 (20.3)	42 (12.72)	38 (11.51)	203	61.52
Heart discomfort	267 (80.9)	-	20 (6.06)	43 (13.03)		63	19.09
Insomnia	211 (63.93)	60 (18.18)	37 (11.21)	22 (6.66)		119	36.06
Joint and muscular pain	55 (16.66)	72 (21.81)	64 (19.39)	82 (24.84)	57 (17.27)	218	66.06
Urogenital domain							
Sexual problems	183 (55.45)	93 (28.18)	54 (16.36)			147	44.55
Dryness of vagina	198 (60)	48 (14.54)	37 (11.21)	32 (9.69)	15 (4.54)	117	35.46
Bladder problems	134 (40.6)	41 (12.42)	69 (20.9)	86 (26.06)	24 (7.27)	196	59.39

Note: # multiple responses

Table 2 shows that out of the total population (n=330), 116 women were in post-menopausal stage and their average age at menopause was 46.22 (±4.39) year. In 34.48% of women menopause was as 40-50 years, whereas, in 25 %, menopause started at the age of 50 years or above. The average age of the onset of menopause has been increasing since the end of the 19th century and is currently 52 years reported by Ganong (2008). The findings of the study is are also similar to the results reported by Singh and Ahuja (2016) and Shah et al. (2004) stating the average age of menopause as 44.6 years and 44.7 years, respectively.

Table 3 illustrates the prevalence of different menopausal symptoms among the respondents under psychological, somato-vegetative and urogenital domains. Under psychological domain irritability, physical and mental exhaustion were observed among 63.93% and 63.33% of the respondents, respectively followed by depression in 56.96% of respondents. Under somato-vegetative domain, joint pain and muscular pain were found to be the most prevalent symptoms which were reported by 66.06% in the studied sample followed by hot flushes and night sweats in 61.51% of menopausal women. However, only 19.09% of menopausal women were found to be suffering from heart discomfort. Under Urogenital domains, bladder problems were most common among 59.39% of respondents, whereas, sexual problems and dryness of the vagina was found in 44.54% and 35.45% of the respondents, respectively. Rahman *et al*. (2010) in their study found 41.6% of women complaining of hot flushes and night sweats. However, a study carried out in Turkey by *Yanikkerem et al. (*2012) reported that hot flashes were found in 79.6% of respondents. Similar results were also found by Rahman *et al.* (2010) *i.e.* physical and mental exhaustion in 67% and insomnia in 52% respondents, depressive mood in 32% and heart discomfort in 18% respondents. The study by Pal *et al. (2013)* revealed that the prevalence of physical and mental exhaustion was found to be much higher *i.e*. 86%, the urogenital problems like bladder problems and vaginal dryness were also much prevalent *i.e.* 56% and 53.3%, respectively. Thus,the study concluded that the variation in the experience of different menopausal symptoms in different areas is dependent on the culture, tradition, food habits, and lifestyles of the participants. (Bairy *et al.,* 2009) However, prevalence of the degree of severity of symptoms experienced by the respondents vary, it was observed that most of the respondents experienced mild to moderate symptoms under all menopausal symptoms domains. Severe symptoms were observed for joint and muscular pain (24.84%), bladder problems (26.06%), irritability (17.87%), physical & mental exhaustion (13.63), heart discomfort (13.03%), hot flashes and night sweats (12.72%). None of the respondents experienced very severe symptoms for psychological domain, heart discomfort and insomina for somato-vegetative domain and sexual problems for urogenital domain. However, very severe symptoms were observed such as hot flushes and night sweat (11.51%), joint and muscular pain (17.27%), dryness of vagina (4.54%)and bladder problem (7.27%) among the respondents.

Table 4. Quality of life of the respondents according to severity of menopausal symptoms (n=330)

S. No.	Quality of life	f	%
1.	Good	30	9.09
2.	Average	72	21.81
3.	Fair	142	43.03
4.	Poor	86	26.06

Table 4 reveals the quality of life of the respondents with reference to the degree of severity of menopausal symptoms prevalent among the respondents. The severity scale was divided into five scores (0-4) from no symptoms to severe experience of symptoms. It was noted that 9.09% of respondents have experienced no symptoms, thus, their quality of life was good, whereas, 21.81% reported mild symptoms and their quality of life was average. However, most of the respondents reported moderate symptoms *i.e.* 43.03%, thus, their quality of life was fair and 26.06% of respondents who experienced most of the symptoms severelyfell underlow quality of life. Similar findings were observed in the survey conducted by *Nisar et al.* (2009) and Khatoon *et al.* (2018) that most of the respondents experienced mild to moderate symptoms.

It was observed that in urban area most of the women were severely affected by the menopausal symptoms *i.e.* 32.42%, whereas, in rural area 28.18% and tribal area 17.27% of respondents' experienced different menopausal symptoms severely (Table 5). Majority of the respondents irrespective of their place of residence (urban, rural and tribal areas) experienced the symptoms moderately *i.e.* 44.54%, 40.9% and 43.63% , respectively. No significant association was found between experiencing of severity of menopausal symptoms with the place of residence of the respondents. Similar findings were reported by by Sharma and Mahajan (2015) who observed that high percentage of scores of MRS was observed in both rural and urban women.

Menopausal status and menopausal symptoms were directly correlated with each other. It is noted from the Table 5 that severity of symptoms were higher in post-menopausal period followed by peri menopause *i.e.* 34.48% and 33.68% respectively, whereas, it was only 11.76% in premenopausal women. There was a significant association found between experience of severity of menopausal symptoms with the menopausal status of the respondents in the study, (X^2=52.074, p<0.01). Similar findings were also reported by Rathnayake *et al.* (2019) who stated that the symptoms scores were higher among postmenopausal women compared to pre-menopausal. When menopausal symptoms were observed by age and its severity was measured, it was recorded that severity of symptoms experienced by the respondents increased with increase in age *i.e.* it was higher in 45-50 years of age groups followed by 50-55 years of age group. Similarly, more percentage of women experienced moderate menopausal symptoms in the age group of 40-55 years *i.e.*

Table 5. Association between menopause symptoms score and socio-demographic variable of the respondents (n=330)

Sl. No.	Item details		No score	Mild score	Moderate score	Severe to very severe score	X^2	P value
1.	Area	Urban (n=110)	7(6.36)	18(16.36)	49(44.54)	36(32.72)	10.308	0.112
		Rural (n=110)	10(9.09)	24(21.81)	45(40.9)	31(28.18)		
		Tribal (n=110)	13(11.81)	30(27.27)	48(43.63)	19(17.27)		
2.	Menopause Status	Pre-menopause (n=119)	22(18.48)	42(35.29)	41(34.45)	14(11.76)	52.074	0.001*
		Peri menopause (n=95)	3(3.15)	16(16.86)	44(46.31)	32(33.68)		
		Post-menopause (n=116)	5(4.31)	14(12.06)	57(49.13)	40(34.48)		
3.	Age	35-40 (n=119)	15(12.6)	40(33.61)	47(39.49)	17(14.28)	26.718	0.001*
		40-45 (n=82)	6(7.31)	14(17.07)	38(46.34)	24(29.26)		
		45-50 (n=75)	6(8)	10(13.33)	31(41.33)	28(37.33)		
		50-55 (n=54)	3(5.55)	8(14.81)	26(48.14)	17(31.48)		
4.	Educational status	Illiterate (n= 94)	11(11.7)	20(21.27)	47(50)	16(17.02)	16.555	0.167
		Primary (n=31)	3(9.67)	9(29.03)	11(35.45)	8(25.8)		
		Middle (n=31)	1(3.22)	12(38.7)	10(32.25)	8(25.8)		
		High School (n=64)	6(9.37)	11(17.18)	26(40.62)	21(32.81)		
		Intermediate (n=65)	6(9.23)	12(8.46)	29(44.61)	18(27.69)		
		Graduation & above (n=45)	3(6.66)	8(17.77)	19(42.22)	15(33.33)		
5.	Occupation	Housewife (n=164)	11(6.70)	37(32.56)	72(43.9)	44(26.82)	2.967	0.965
		Labour (n=74)	8(10.81)	16 (21.62)	33 (44.59)	17 (22.97)		
		Worker (n=47)	6(12.75)	9(13.14)	19(40.42)	13(27.65)		
		Professional (n=45)	5(11.11)	10(22.22)	18(40)	12(26.66)		
6.	Income	5000-9,999 (n=113)	12(10.61)	23(20.35)	50(54.24)	28(24.77)	5.183	0.951
		10,000-14,999 (n=45)	5(11.11)	12(26.66)	15(33.33)	13(28.88)		
		15,000-19,999 (n=37)	2(5.4)	9(24.32)	16(43.24)	10(27.02)		
		20,000-24,999 (n=23)	1(4.34)	7(30.43)	10(43.47)	5(21.73)		
		25,000-29,999 (n=33)	2(6.06)	9(27.27)	12(36.36)	10(30.3)		
		30,000 & above (n=79)	8(10.12)	12(15.18)	39(49.36)	20(25.31)		

41.33% to 48.14% when compared to women of 35-40 years of age. Experiencing no symptoms and mild symptoms were found more among 35-40 years age group of respondents. There was a significant association found between experienced of severity of menopausal symptoms with the current age of the respondents in the study, (X^2=26.718, $p<0.01$).The prevalence of menopausal symptoms scores were found to be increased with advancement of age. The severity of symptoms found more in older group than the younger ones. This finding is also supported by Khatoon *et al.* (2018) and other studies conducted in India. When severity of symptoms and educational qualification was associated, it was observed that experiencing no symptom was more in illiterate group *i.e.*11.7% and lowest in middle education group 3.22%. However, at the same time 50% of the illiterate women had experienced moderate symptoms followed by 42.22% of highly educated women. The severity of symptoms was more prevalent in highly educated women *i.e.* 33.33% followed by 32.81% women having high school qualification and least were found in illiterate group *i.e.* 17.02%. Hence, it shows that with increase in educational level the severity symptoms also increased. This might be due to less of physical exercise, more use of modern gadget and faulty life style. There was no significant association found between experienced of severity of menopausal symptoms with the level of education of the respondents in this study. Association of menopause symptoms score with occupation of the respondents showed that more percentage of respondents experienced moderate symptoms irrespective of type of occupation; however, it was higher in labourers. No symptom was severe among professionals; mild symptoms were more among housewives and severe symptoms was higher among workers. There was no significant association found between experience of severity of menopausal symptoms with the type of occupation of the respondents.

Association of severity of symptoms with their family income showed that more percentage of respondents reported no symptoms belonged to Rs.10,000- Rs.14,999/- income group *i.e.* 11.11% followed by 4.34% of respondents belonged to Rs.20,000- Rs. 24,999/- income group. Mild symptoms were most prevalent in respondents belonged to Rs.20,000- Rs.24,999 income group *i.e.* 30.43% followed by Rs.25,000- Rs.29,999/- income group. The prevalence of moderately affected menopausal women *i.e.* 49.36% were from Rs. 30,000 and above income group, whereas, it was 54.24% in Rs.5000- Rs. 9,999/- income group. Most severely affected women *i.e.* 30.3% had Rs.28,000-Rs.29,999/- income followed by 28.88% of women from Rs.10,000 - Rs.14,999 income levels. There was no significant association found between experienced of severity of menopausal symptoms with the monthly income of the respondents in the study.On the other hand, demographic variables such as educational status, occupation and family income in relation to domain wise menopausal symptoms score were found to be statistically insignificant. It was noted that with advancement of educational level the menopause symptoms score were also increased *i.e.* women with intermediate education and higher level of education reported more menopause symptoms score. It was observed that educational level and menopause symptoms score were inversely related to each other in the research findings of Gold *et al.* (2006). The study conducted by Joseph *et al.* (2014) reported that educated women had more severe symptoms which is similar to the results of this study. Similarly, prevalence of menopausal symptoms score was found to be higher in professional women when compared to worker groups. It was also observed that there was increase in menopause symptoms score with increase in income of family. Women who had above Rs.25,000/- monthly family income reported more symptoms compared to other income groups. The risk factors for more severe menopausal symptoms were also related to income level and low income relates to more severe problems as reported by Lee *et al.* (2008) and Khtoon *et al.* (2018). The proportion of difference was found to be statistically significant and, hence, contradict with the result of this study.

CONCLUSION

Average age of menopause was 46.22 years. The most prevalent symptoms found among the respondents were irritability, depression, hot flashes, night sweats, joint pain, and muscular pain. The menopausal status (pre, peri, post), and current age of the respondents have shown a significant association in experiencing different menopausal symptoms. Due to the prevalence of the severity of symptoms, fair quality of life was experienced by the respondents in their post-reproductive life. Thus, it is suggested that all women should be educated regarding the effect of menopause in later life and awareness should be created to care for them from the beginning. Moral support should be given to the menopausal women from their family and society and government should implement different health programs for elderly women to make their post-menopause life a productive one.

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IMPACT OF COVID-19 PANDEMIC ON COFFEE PRODUCTION AND EXPORTS IN INDIA

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Coffee is the second most important beverage crop of India next to the tea. There are about 2,50,000 coffee growers in the country; 98 percent of them are small farmers. Coffee is grown in three regions of India with Karnataka, Kerala and Tamil Nadu forming the traditional coffee-growing region, followed by the new areas developed in the non-traditional areas of Andhra Pradesh and Orissa in the eastern coast of the country and the third region being the states of Assam,Manipur, Meghalaya, Mizoram, Tripura, Nagaland and Arunachal Pradesh of North-eastern India (Hiralal *et al.,* 2019).

The two well-known species of coffee grown are the *Arabica and Robusta* and the country accounts for 3.14 percent of global coffee production. Indian coffee area and production over the years are increasing and it was estimated in 2018-19 that coffee bearing area, production, and productivity were 4,16,741 ha, 3,19,500 MT and 767 kg ha^{-1}, respectively (Coffee Board of India*,* 2020).

India is the third-largest producer and exporter of coffee in Asia and the sixth-largest producer and fifth-largest exporter of coffee in the world. Of the total coffee produced in India, 70 percent is exported and 30 percent is consumed domestically. Italy is the leading importer of coffee (21.60% in 2019-20) .The other importers of coffee are Germany, Russia, Poland, Turkey, Slovenia, Jordan, Kuwait, Libya. India exported 350159.97 tonnes of coffee and earned about Rs. 5814.60 crores in 2019 (Table 1).

World Bank estimates about 25 million families produce and sell coffee for their livelihood and most of them are small-scale farmers with limited financial resources and scope to diversify out of coffee(Bryan *et al.,* 2004).The coffee industry depends on the labour of millions of transient workers who arrive on coffee farms all over the world during the harvest to pick coffee. Labour represents the largest cost of production for coffee farming.

In India, as coffee is a major export earner, the study was taken to assess the impact ofthe COVID-19 pandemic on coffee production concerning labour, since labour is major input required for all the operations right from planting to harvesting.Farmers cultivating coffee in India depend upon migrant labourers who are now facing the heat of reverse migration of workers. Out of an estimated five lakh migrant workers, at least half of them are being from North and

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North-East India to execute seasonal works. During the pre-lockdown and lockdown period, majority of them have returned to their native places.

Karnataka grows about 70 percent of the coffee produced in India. The wages paid in Karnataka are three times higher when compared to their home states and even planters were unable to meet the increasing demands of local labourers and also there is non-availability of local labourers'. On top of the systemic challenges besetting the plantation sector, the onset of the COVID-19 pandemic in the first quarter of the year 2020 is seen to have further threatened the overall capacity of the sector to achieve productivity and income targets. The imposition of mobility restrictions and community quarantine lockdowns as a direct response to the COVID-19 pandemic resulted in the creation of supply and demand shocks in coffee supply chain management. In turn, this would impact on the plantation sector's immediate and long-term economicperformance. Hence, this paper aimed to shed light on the impact of the COVID-19 pandemic on coffee production and exports in India.

COVID-19 has affected labour supplies and hence impacting coffee plantation sector production in India. In this study, these measures were analysed through estimation of the percent change in the output of coffee production. Within such predicted global slowdown, Vos *et al.* (2020) estimated that the reduced labour mobility would lead to a 1.4 percent reduction in labour supply using the approach developed by the International Food Policy Research Institute (IFPRI). Based on the above study,Glenn *et al.* (2020) computed the agricultural labour force (ALF) in 2020 with a 1.4 percent drop from the ALF in 2019 in their study on assessing the impact of the COVID-19 pandemic on agricultural production in South-East Asia.

Using these estimates, the coffee labour force (CLF) in 2020 was computed with a 1.4 percent drop from the CLF of coffee in 2019 in India. Secondary data from the Coffee Board was used in the analysis covering the most recent five-year statistics (2015- 2019). Specifically, the data collected and used in the analyses included (a) coffee labour force and (b) volume of coffee production (in MT).

The change in the volume of coffee production was estimated through projected volume for 2020 with the calculation of coffee labour productivity using 2018 volume of productionand estimated coffeelabour force in 2020 (the base year 2018). The annual coffee production per worker, which is the ratio of the volume of coffee production to the total number of employed persons in the coffee sector, was used to estimate the volume of coffee production for 2020. As applied in this study, the reduction in the volume of coffee production from 2019 to 2020 due to a 1.4 percent decrease in the coffeelabour force was quantified and valued in terms of its monetary values/measures.

According to the International Coffee Organization (ICO, 2020),there is a strong correlation between the gross domestic product in the main industrialized countries and the demand for coffee.

The present crisis in the Indian coffee sector is due to the imposition of community lockdowns.This would in turn resulted in reduced coffee production in the country during 2020-

21. The reduced production in the coffee is also caused by the farmer's limited access to the various inputs required and transportation facilities to take the product to the markets, which may result in losses and even wastage of the produce.The COVID-19 pandemic represents a further challenge to the coffee sector which was already suffering a prolonged period of stagnant production and low prices(Mariano, 2020). Although governments are implementing policies to save lives and mitigate economic damage, a global economic recession is now certain with an initial rapid decline in economic growth and an increase in unemployment.

Among the coffee-producing states in India, Southern states stood in the top spot especially Karnataka, Kerala, and Tamil Nadu with a share of 69 percent, 22 percent and six percent, respectively. The restrictions caused by COVID-19, during the first quarter of the year 2020 translate to a 1.4 percent drop in farm labour supply as estimated by Vos *et al.* (2020). This has caused an overall decline in coffee production amounting to 4473 metric tonnes for the whole country (Table 2). Among coffee producing states the most affected states in the reduced coffee production due to decline in the coffee labour supply are, Karnataka (3074 MT), followed by Kerala (986 MT), Tamil Nadu (249 MT), non-traditional areas includes Andhra Pradesh and Orissa (162 MT) and the North-Eastern states (3 MT). If the reduction in coffee production is estimated in terms of monetary terms, it could become around Rs.75 crores. For Coorg and Malabar regions of Karnataka and Kerala, whose population is heavily based on the coffee sector, the disruption caused by the COVID-19 pandemic poses the risks of unemployment, which, if unabated sooner, will eventually result to a widespread reduction in living standards due to limited capacity and access to necessities.

India's coffee exporters are amidst deep financial crisis with the state and central governments announcing a lockdown to curtail the spread of Covid-19 across the country. The banning of coffee exports from India to Europe had an unprecedented impact on the Indian Coffee Industry.As a result, approximately 21,000 metric tonnes of coffee valued at over Rs.400 crores is stuck at coffee curing centres and various ports for non-availability of permissions to export.

Coffee curing centres in Chikkamagaluru, Kushalnagar (Kodagu district), Mangaluru and other places are currently holding an estimated 20,000 metric tonnes of coffee and another close to 1,000 tonnes are lying at Mangaluru, and Kochi ports for lack of shipment permits (Deccan Herald, 2020).

Italy, which is the largest market for Indian Robusta and where nearly 65,000 tonnes are imported annually, is anticipating a 10-12 percent drop in consumption due to the Covid-19 outbreak and related restrictions. As a result, the country's overall coffee exports both quantity-wise and value-wise has come down by around 14.12 percent and 9.01 percent, respectively for July 2020 as compared to July 2019 (Fig.1).

While the plantation sector in the South Indian states of Karnataka and Kerala anticipates huge losses due to Covid-19, coffee prices have been on the rise due to high demand and low supply, which is a trend that is likely to continue.

According to the Coffee Board of India, as on April 24, 2020, Robusta prices based on The London International Financial Futures and Options Exchange (LIFFE) is expected to raise from Rs. 85.49 per kg (May 2020) to Rs.101.76 per kg (November 2020).

However, coffee consumption may also contract as a result of the containment measures against the spread of COVID-19, particularly for out-of-home consumption. Furthermore, disruptions to the supply chain both in shipping and harvesting could lead to temporary shortages in the supply and leads to convergence in the elasticity of the demand curve. As a result, demand creates upward pressure on prices in the short term(Shruti, 2020).

Coffee sector is affected by Covid-19 pandemic. It is reported from this study that the pandemic has decreased production as well as exports. To face this type of situation,shortly domestic processing and storage needs to be increased rather than solely depending only on earnings from exports.

Table 1. Global scenario of coffee

Export of Coffee and its earnings (MT)						
Year	**Arabica**	**Robusta (GBE)**	**Instant (GBE)**	**Roasted**	**Total**	**Earnings (Rs. Crores)**
2018	53303.00	179904.58	116702.02	371.25	350280.85	6159.24
2019	47328.93	186200.87	116354.88	275.30	350159.97	5814.60
2020*	27060.50	84379.77	44050.46	107.65	155598.39	4131.82

GBE: Green Bean Equivalent Note: *: up to 11.06.2020; Source: Coffee Board of India, Bengaluru (2020)

Table 2. Estimated reduction in the volume of coffee production due to decrease in agricultural labour force in India

States	No. of labours	Production (MT)	Labour Productivity	Estimated labour Force	Estimated Production (MT)	Change in Production (MT)
Karnataka	515792	219550	0.43	508571	216476	-3074
Kerala	44194	70435	1.59	43575	69449	-986
Tamil Nadu	31235	17765	0.57	30798	17516	-249
Non-traditional areas	67723	11550	0.17	66775	11388	-162
North-Eastern Regions	5562	200	0.04	5484	197	-3
India	664506	319500	0.48	655203	315027	-4473

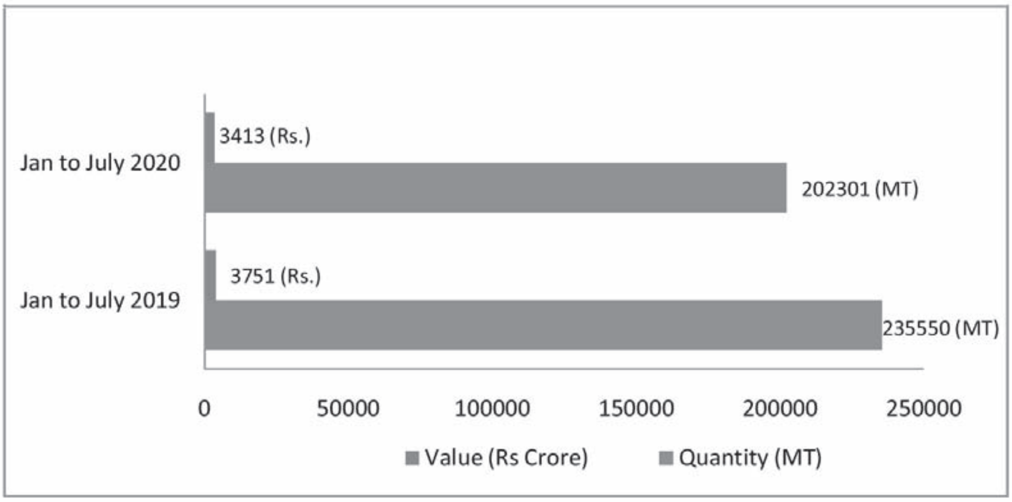

Fig.1. Export of Coffee from India

Source: Coffee Board of India, Bengaluru (2020)

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KNOWLEDGE, ATTITUDE AND PRACTICE (KAP) SURVEY TO ASSESS THE EFFECT OF ENTREPRENEURSHIP TRAINING PROGRAMME

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The growth and development of any economy is dependent upon multiple factors and one of the most prominent one is financial growth. Financial growth is achieved through the better utilization of human resources. Women are turned to be better contributors of the economy through entrepreneurial ventures (Kaur and Batra, 2018).The participation of women in economic activities is necessary not only from a human resource point of view but also essential for raising the status of women in society. The emergence of women entrepreneurs and women owned firms and their significant contribution to the economy is visible in India (Charantimath, 2006).Women entrepreneurs are those women who think of a business enterprise, initiate it, organize and combine the factors of production, operate the enterprise and undertake risks and handle economic uncertainty involved in running a business enterprise (Kumar, 2015).

Entrepreneurship training programme is a continuous process of training and motivating potential and existing entrepreneurs to set up profitable enterprises. It is a process to increase motivational skills and knowledge, create and improve entrepreneurial behaviour and help in developing own venture after implementing the programme (*Chole et al., 2012*).

A study was taken upto identify the socio-economic profile of the selected women trainees in Kottukal Panchayath of Thiruvananthapuram district in Kerala and to analyse theKnowledge, Attitude and Practice (KAP) levels of the women trainees before and after participating in the entrepreneurship training.

Fifty women wereselected through purposive sampling method from Kottukal Panchayath of Thiruvananthapuram district in Kerala. Survey method was adopted using a questionnaire termed as KAP (Knowledge, Attitude and Practice)tool to collect primary data.Secondary data was collected from newspapers, books, journals, websites, and so on. Pilot study was conducted among ten women from Kottukal Panchayath in order to check the feasibility of the KAP Tool. The tool consisted of ten statements each for variables like Knowledge, Attitude and Practice. The knowledge statements were rated at three point scale as agree, undecided and disagree with scores of 3, 2 and 1, respectively.The attitude statements were rated at five point scale as strongly agree, agree,

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neutral, disagree and strongly disagree with scores of 5, 4, 3, 2 and 1, respectively. The practice level statements were rated at three point scale as ‘yes’, ‘not sure’ and ‘no’ with scores of 3, 2 and 1, respectively. Before starting the training, the tool was used to collect data on knowledge, attitude and practice levels of the women trainees. The three days entrepreneurship training programme was framed and implemented with the help of entrepreneurship trainers. Paired sample t test was used to assess the change in knowledge, attitude and practice. Mean value is calculated by adding up the scores obtained by each women trainee and dividing it by the number of women trainees.

The socio- economic profile of the women trainees revealed that 34 percent of the women trainees come under the age group of 31- 40 years, more than half of the respondents (62 percent) were Hindus, 56 percent were married, 38 percent had acquired high school level education, 70 percent were from nuclear families, 82 percent were home makers and 52 percent had monthly earnings below Rs.10,000/-.

A. Knowledge level of the women trainees before and after the training

Table 1. Knowledge level of the women trainees before and after the training (n=50)

Statement	Mean		t-value	Significance
	Before training	After training		
Paper bag making requires heavy machineries	2.4000	3.9000	-2.280	.027**
Cloth pouch dimension varies from 13cm´12cm to 41cm´62cm	2.3800	3.1400	-3.418	.001*
Hanging type of coconut shell soap dish have more cost of production than plastic soap dish	2.4800	3.4000	-3.455	.001*
Reed basket making is supported by Bamboo Development Corporation	2.2400	3.9200	-8.363	.000*
Business proposal is the blue print for entrepreneurship building	2.4600	3.4000	-3.011	.004*
Business success is measured by tracking profit and loss	2.1800	3.4000	-4.445	.000*
New distribution channels are necessary for business growth	2.3400	3.1400	-3.233	.002*
Packaging and labelling should be standardized	2.0600	3.8800	-5.277	.000*
Work- life balance is the right mix for business success	2.1000	3.2800	-6.248	.000*
Start Up India Programme promotes entrepreneurs	2.2600	2.7400	-1.607	.114

***Significant at 1% level; **Significant at 5% level**

It is inferred from the Table 1 that more number of variables are significant at one percent and five percent levels which shows that the knowledge level of the women trainees had increased considerably after attending the training programme. Similarly,Clercq and Arenius (2006) in their study stated that exposure to knowledge is positively correlated with the probability of getting involved in entrepreneurship and training programmes improve the knowledge level of beneficiaries to a certain extent.

Table 2 shows that the attitudinal change was brought about after the training and the values suggest room for improvement when comparing the result brought about by the knowledge increment. Much effort is needed to bring about positive attitudinal change. The study of Anggadwita and Dhewanto (2016) states that women entrepreneurial intention get influenced by personal attitude which in turn is influenced by psychological characteristics, individual competence and social perceptions, which implies that inculcating attitudinal change is a complex process.

B. Attitude level of the women trainees before and after the training

Table 2. Attitude level of the women trainees before and after the training (n=50)

Statement	Mean		t-value	Significance
	Before training	After training		
Engaging in entrepreneurship helps to improve family status	2.0600	2.4000	-2.503	.383
Contacts and networking linkages improve through entrepreneurship	1.8000	2.3000	-2.907	.085
Entrepreneurship helps to improve marketing arenas	1.9600	2.6000	-4.251	.000*
Entrepreneurship provides better working environment	2.0200	2.1600	-.880	.000*
Entrepreneurship motivate people	1.9000	2.1600	-1.757	.063
Entrepreneurship is a rewarding career	1.6000	2.2200	-3.843	.166
Self- development is possible through entrepreneurship	1.5200	2.5600	-7.010	.000*
Entrepreneurs are profits to an economy	2.1000	2.3400	-1.899	.383
It is good to take loans for enterprise building	2.0200	2.2800	-1.407	.085
Risk taking is a part of entrepreneurship	1.9200	2.6400	-4.846	.000*

***Significant at 1% level**

C. Practice level of the women trainees before and after the training

Table 3. Practice level of the women trainees before and after the training (n=50)

Statement	Mean		t-value	Significance
	Before training	After training		
Engaging in entrepreneurship helps to improve family status	2.0600	2.4000	-2.503	.383
Have you ever attended any entrepreneurship training?	1.4600	1.9000	-2.955	.005*
Are managing your time properly?	1.8200	1.4200	2.800	.007*
Did you ever worked in a group?	1.5600	1.6600	-.616	.541
Have you used your skills profitably?	1.4800	1.9200	-2.759	.008*
Have you visited any enterprise to know about its working?	1.6200	2.6400	-8.536	.000*
Have you interacted with any entrepreneurs?	2.4000	3.9000	-2.280	.027**
Have you approached any financial institution to seek loan for business purpose?	1.4600	1.5800	-.814	.420
Do you have experience in social media marketing?	1.8000	1.8400	-.170	.866
Have you ever invested money in entrepreneurship?	1.3600	1.8800	-3.066	.004*
Have you ever tried to start a joint venture?	1.4000	1.3000	.896	.374

***Significant at 1% level; **Significant at 5% level**

It is observed in Table 3 that the values are statistically significant,which infers a positive trend in terms of entrepreneurship related practice aspects of the women trainees. Findings of Bharadwaj (2004) also suggested that training have positive impact on the entrepreneurial practice of women.

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