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Assessment of Genetic Diversity of Bunch Groundnut (*Arachis hypogaea* L.) Genotypes Collected from Various Parts of India

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ABSTRACT

The present study was carried out to assess genetic diversity among 58 genotypes of bunch groundnut using D^2 statistics during *kharif* – 2018 in randomized block design with three replications at the instructional farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh for thirteen agro-morphological characters viz., days to flowering, days to maturity, plant height, number of primary branches per plant, number of mature pods per plant, pod yield per plant, 100-pod weight, kernel yield per plant, 100-kernel weight, sound mature kernel, biological yield per plant, harvest index and oil content. The 58 groundnut genotypes were grouped under 11 clusters. Among 11 clusters, cluster IV was the largest comprising 18 genotypes, followed by cluster I, comprising 17, Cluster II has 12, cluster III has 4 and cluster V to XI were solitary. The D^2 values for inter-cluster distances, showed maximum between cluster VI and X (19.71), followed by VI and VII (18.77), V and X (18.68), III and V (18.65), V and VII (18.62), II and V (17.86), V and VIII ($D = 17.78$), III and X ($D = 17.43$) and VI and VIII ($D = 17.20$). The clusters were ranked based on the overall score across all thirteen characters. Accordingly, cluster III was the best for days to maturity, number of mature pods per plant (DH-24 and ICGV-0642), pod yield per plant (DH-221 and DH-201), kernel yield per plant and sound mature kernel (DH-55 and AH-34-90). Cluster VIII, X and XI were best for oil content (ICGV-03109 and AK-159), harvest index and biological yield per plant, respectively. Each character had their own contribution toward genetic divergence where, 100 kernel weight and sound mature kernel (%) has a maximum contribution of 23.71% and 23.23%, respectively.

Key words: D^2 statistics, Bunch groundnut, Solitary, Cluster distance and Contribution.

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is one of the world's most important legume crop. The word groundnut (*Arachis hypogaea* L.) is derived from the Greek word "*Arachis*" meaning legume and "*hypogaea*" meaning below ground. It is commonly known as peanut, monkey-nut and goobernut. The genus *Arachis* is a member of family

Fabaceae (Synonym: Leguminosae), subfamily Papilionoidea, tribe Aeschynomeneae and sub-tribe stylosanthinae. It belongs to the section *Arachis* and series amphiploidies and the family Fabaceae (Gregory *et al.*, 1980). Southern Bolivia and Northern Argentina are thought to be the centre of origin of this crop (Kochert *et al.*, 1996) and the centre of diversity for this genus includes Western

Brazil, Bolivia, Paraguay, and Northern Argentina. Having the basic chromosome number of $x=10$ (Stalker, 1991) peanut is an allotetraploid ($2n=4x=40$). Obviously, allopolyploid crops have complex genome. This may lead to more diversity in groundnut genotypes.

This is widely grown in the tropics and subtropics, being essential to both small and large commercial producers. Groundnut requires 20°C - 30°C of temperature and 50 cm to 100 cm of rainfall. Like most other legumes, peanuts harbour symbiotic nitrogen-fixing bacteria in root nodules. This capacity to fix nitrogen means peanuts require less nitrogen-containing fertilizer and can improve soil fertility, making them valuable in crop rotations.

The genetic divergence analysis determines the variation pattern in the collection of genotypes, identify the contributing characters and differentiates the genotypes

into different groups that could be used in the improvement programme. Genetic diversity plays an important role because hybrids between lines of diverse genetic backgrounds generally display a greater heterosis than those between closely related parents and may generate broad-spectrum genetic variability in segregating generations (Arunachalam, 1981; Sharma, 1998). Moreover, estimating genetic diversity among genotypes through Mahalanobis' D^2 technique is very useful for selecting diverse parents.

MATERIALS AND METHODS

The present investigation was carried out to assess genetic divergence in fifty-eight diverse genotypes of bunch groundnut (*Arachis hypogaea* L.) representing different geographic origins across India. The required quantity of seeds for this experiment have

Table 1: Distribution of fifty-eight groundnut genotypes into the different clusters by Tocher's method

Cluster No.	No. of strain	Genotypes included in the cluster
I	17	DSA-201, AMR-43, C-817, AH-8986, EC-21147, AK-7223, AK-135, EC-21048, EC-1283, AMR-22, ALR-2, EC-21121, AH-8253, AH-8189, ICGV-06050, AH-34-90 and ICGV-91040
II	12	AMR-42, AH-7217, EC-2100-8, 68-135, GG-5, CO-2, AK-400, TCGS-1043, EC-100827, EC-21051, 52-35, ALR-1
III	4	DH-24, DH-221, DH-55 and DH-201
IV	18	EC-1697, AK-5144, ALR-3, GG-3, ICGV-03042, ICGS-11, ICGV-90116, EC-21126, AK-159, FE-ESG-10, ICGV-03109, EC-21057, AH-7220, ICGV-06424, ICGV-05030, ENGEUZM, ICGV-86325 and ICGV-06041
V	1	CUL-1-5-3
VI	1	DH-40
VII	1	GG-7
VIII	1	ICGV-06424
IX	1	AMR-49
X	1	ICGV-89359
XI	1	ICGV-06188

Table 2: Source and clustering pattern for fifty-eight genotypes of bunch groundnut (*kharif*)

Source	ICRISAT, Hyderabad	UAS, Dharwad	PAU, Ludhiana	TNAU, Aliyarnagar	TNAU, Tindivanam	TNAU, Coimbatore	PDKV, Akola	ANGRAU, Tirupati	JAU, Junagadh	Unknown
I	6	-	1	1	4	-	2	-	-	3
II	3	-	-	1	1	1	1	1	1	3
III	-	4	-	-	-	-	-	-	-	-
IV	11	-	-	1	1	-	2	-	1	2
V	-	-	-	-	-	-	-	-	-	1
VI	-	1	-	-	-	-	-	-	-	-
VII	-	-	-	-	-	-	-	-	1	-
VIII	1	-	-	-	-	-	-	-	-	-
IX	-	-	-	-	-	-	-	-	-	1
X	1	-	-	-	-	-	-	-	-	-
XI	1	-	-	-	-	-	-	-	-	-
Total number of genotypes	23	5	1	3	6	1	5	1	3	10

Table 3: Average intra (diagonal) and inter (above diagonal) cluster D values for fifty-eight genotypes of bunch groundnut (*kharif*)

	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8	Group 9	Group 10	Group 11
Group 1	6.75	10.09	9.94	11.20	12.17	10.13	15.36	11.02	11.12	15.37	12.59
Group 2		7.59	9.75	14.56	17.86	16.08	14.26	9.28	15.58	12.96	11.47
Group 3			7.92	14.55	18.65	14.35	16.70	10.26	16.43	17.43	13.04
Group 4				10.37	11.82	11.77	13.28	13.80	11.99	15.27	11.45
Group 5					0.00	9.30	18.62	17.78	8.54	18.68	16.43
Group 6						0.00	18.77	17.20	8.81	19.71	15.30
Group 7							0.00	14.33	15.90	8.63	8.36
Group 8								0.00	15.95	14.14	10.24
Group 9									0.00	16.71	14.41
Group 10										0.00	9.72
Group 11											0.00

Table 4: Cluster means for fourteen characters in bunch groundnut (*kharif*)

	Days to flowering	Days to maturity	Plant height (cm)	No. of primary branches per plant	No. of mature pods per plant	Pods yield per plant (g)	100 pods weight (g)	Kernel yield per plant (g)	100 kernel weight(g)	Sound mature kernel (%)	Biological yield per plant (g)	Harvest index (%)	Oil content (%)
Group 1	32.14	104.27	39.18	3.06	9.25	9.92	95.67	7.29	39.10	85.51	22.29	41.43	48.53
Group 2	32.08	102.50	38.53	3.08	8.19	9.36	118.83	6.61	48.94	82.83	21.25	43.61	48.36
Group 3	33.42	102.42	41.17	3.00	11.83	11.92	114.58	8.58	47.33	86.83	30.67	41.00	47.67
Group 4	31.83	100.24	35.07	3.00	9.93	9.80	89.89	7.19	34.81	74.56	26.72	36.33	48.94
Group 5	29.67	103.33	36.00	3.00	6.33	5.33	61.67	3.67	26.67	82.67	19.00	28.67	49.67
Group 6	34.33	107.00	41.00	3.00	8.33	9.00	76.33	6.33	30.67	83.33	29.67	31.00	45.33
Group 7	32.00	99.67	38.00	3.00	10.00	11.00	114.00	7.67	45.33	54.33	23.33	41.00	48.67
Group 8	34.33	100.67	35.00	3.00	9.67	11.33	114.00	8.33	49.33	82.33	32.33	34.67	52.67
Group 9	30.00	113.67	42.00	3.00	7.00	7.67	75.33	5.00	33.00	71.67	26.67	29.00	49.00
Group 10	36.33	102.67	25.67	3.00	6.00	9.33	108.00	7.00	51.00	62.00	12.67	53.67	47.00
Group 11	33.67	96.67	34.33	3.00	7.67	9.33	109.33	6.33	48.00	66.67	33.33	26.00	47.67

Table 5: Contributions of various characters to divergence

Sr. No.	Characters	Times Ranked 1 st	Contribution (%)
1	Days to flowering	3	0.18
2	Days to maturity	127	7.68
3	Plant height (cm)	1	0.06
4	No. of primary branches per plant	0	0.00
5	No. of mature pods per plant	137	8.29
6	Pods yield per plant (g)	12	0.73
7	100 pods weight (g)	279	16.88
8	Kernel yield per plant (g)	0	0.00
9	100 kernel weights (g)	392	23.71
10	Sound mature kernel (%)	384	23.23
11	Biological yield per plant (g)	149	9.01
12	Harvest index (%)	2	0.12
13	Oil content (%)	167	10.10

been obtained from the Main Oilseeds Research Station, Junagadh Agricultural University, Junagadh and it was sown in *kharif*-2018 at the Instructional Farm, Department of Agronomy, J.A.U., Junagadh. For qualifying the diversity in fifty-eight genotypes for thirteen quantitative genotypes viz., days to flowering, days to maturity, plant height, number of primary branches per plant, number of mature pods per plant, pod yield per plant, 100-pod weight, kernel yield per plant, 100-kernel weight, sound mature kernel, biological yield per plant, harvest index and oil content and their fitness was assessed using the concept of Mahalanobis' (1936) D^2 statistics.

RESULTS AND DISCUSSION

The genetic diversity among 144 genotypes for 13 characters was measured by employing D^2 statistic. Based on D^2 values, the genotypes were clustered using Tocher's method as given by Rao (1952). In all, eleven

clusters were formed from fifty-eight genotypes. The composition of clusters is given in Table 1 and clustering pattern as accordance to geographical region is shown in Table 2. Among 11 clusters, cluster IV was the largest comprising 18 genotypes, followed by cluster I comprising 17, Cluster II has 12, cluster III has 4 and cluster V to XI were solitary.

It was observed that the maximum intra-cluster distance was found in cluster IV followed by cluster III, cluster II, cluster I and the remaining cluster were solitary. The maximum inter-cluster distance ($D = 19.71$) was found between clusters VI and X followed by that between clusters VI and VII ($D = 18.77$), V and X ($D = 18.68$), III and V ($D = 18.65$), V and VII ($D = 18.62$), II and V ($D = 17.86$), V and VIII ($D = 17.78$), III and X ($D = 17.43$) and VI and VIII ($D = 17.20$). This also suggested that the genetic architecture of the genotypes in one cluster differs substantially from those included in another cluster (Table 3).

The minimum inter-cluster distance ($D=8.36$)

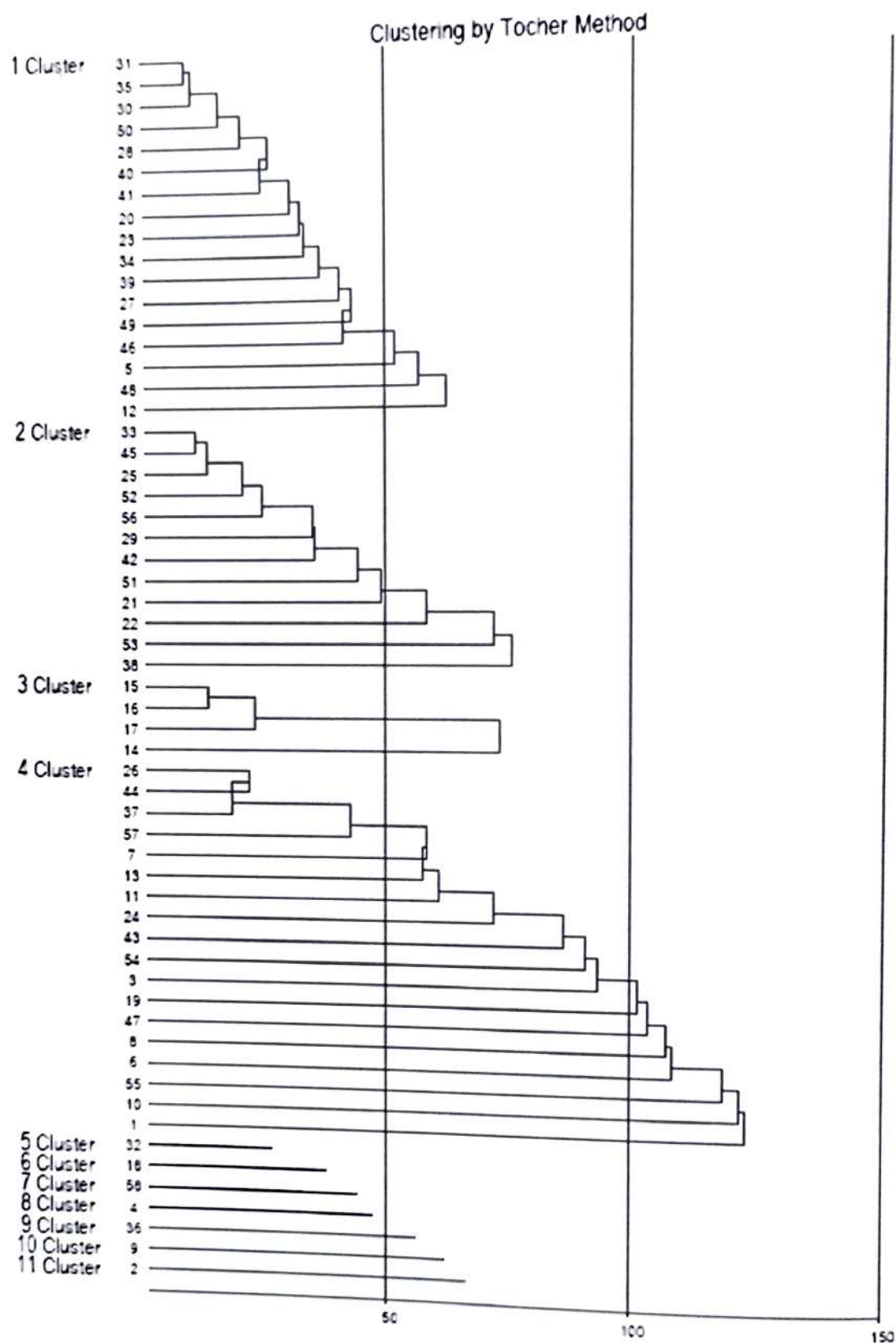


Fig. 1: Cluster diagram representing genetic diversity in studied genotype of bunch groundnut

was found between clusters VII and XI. The lower inter-cluster D values between these clusters suggested that the genetic constitution of the genotypes in these clusters were in close proximity (Table 3).

Based on cluster means of thirteen characters (Table 4), it was observed that the cluster III recorded the highest mean for number of mature pods per plant, pods yield per plant, kernel yield per plant and sound mature kernel.

Percent contribution of various characters for divergence is given in Table 5. Out of thirteen characters studied, the character 100 kernel weight (23.71) contributed the highest for divergence followed by sound mature kernel (23.23), 100 pods weight (16.88), oil content (10.10), biological yield per plant (9.01), number of mature pods per plant (8.29), days to maturity (7.68), pods yield per plant (0.73), days to flowering (0.18), harvest index (0.12) and plant height (0.06) while, number of primary branches per plant (0.00) and kernel yield per plant (0.00) have no contribution. These observations were following observations of Singh and Kaur (1993) and Foundra et al. (2000).

Based on the aforesaid study in present investigation, genotypes DH-221, DH-201, DH-24, ICGV-06424, 68-135, EC-21051, DH-55, AH-34-90, ICGV-03109, AK-159 and 52-35 were found to be superior genotypes for further breeding programme.

CONCLUSION

The diversity study is a prerequisite for the hybridization programme. Most of the time, selecting parents blindly based on phenotypic appearance will not give a satisfactory result. The selections of parents based on intra and inter-cluster distance and cluster mean helps in production of transgressive segregates or better recombinants. According to present divergence study, out of thirteen characters

100 kernel weight, sound mature kernel, 100 pods weight, oil content, biological yield per plant, number of mature pods per plant and days to maturity contributed more than 98% so, we can directly focus on these characters for selection in groundnut.

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Effect of *Glomus* Species on Success and Survival of Jamun Grafts in Relation to Chlamydospores and Percent Root Colonization

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ABSTRACT

An experiment was conducted to assess the effect of three *Glomus* species on the percent success and survival of jamun grafts in relation to the chlamydospores and root colonization behavior. A factorial completely randomized design experiment was conducted by the soil inoculation of three *Glomus* species fungi namely *Glomus fasciculatum*, *Glomus leptotichum* and *Glomus intraradices* to jamun seeds (cultivated and wild) sown in polybags at five grams per polybag. The chlamydospores count and percent colonization at two stages i.e. one month after sowing and grafting stage was done from the soil and expressed in numbers per 50 grams and percentage respectively. Cultivated jamun rootstocks inoculated with *Glomus fasciculatum* exhibited significantly maximum spore population in the rhizosphere of one month old rootstocks (242.00) and at grafting stage (519.00), while significantly minimum spore population was recorded in uninoculated rootstocks at one month after sowing (23.33) and at grafting stage (91.00). Wild jamun rootstocks inoculated with *Glomus fasciculatum* recorded significantly maximum spore population in the rhizosphere of one month after sowing (175.66) and at grafting stage (421.33). Higher root colonisation was observed in mycorrhiza inoculated seedlings compared to uninoculated seedlings. Wild jamun rootstocks inoculated with *Glomus fasciculatum* recorded significantly higher root colonisation at one month after sowing (80.00%) and at grafting stage (82.00%) which was on par with rootstock inoculated with *Glomus leptotichum* at one month after sowing (78.20%) and at grafting stage (80.00%). Zero root colonisation was recorded in uninoculated seeds one month after sowing (0.00%) and at grafting stage (5.50%).

Key words : *Syzygium cuminii*, AM fungi, Per cent root colonization

INTRODUCTION

The jamun (*Syzygium cuminii* (L.) Skeels), a member of family Myrtaceae is one of the important underutilized fruits widely distributed throughout tropic and subtropics as stray plantation or avenue. It is native to India or East Indies. In India, the maximum number of jamun trees is found scattered throughout the tropical and subtropical regions. It also occurs in the lower ranges of the Himalayas up to an elevation of 1300 m and in the Kumaon hills up to 1600 m.

The modern horticulture largely depends upon use of high cost inputs such as chemical fertilizers, pesticides, herbicides, improved seeds, assured irrigation, scientific management and labour saving with energy intensive farm machinery. The application of such high input technology has undoubtedly increased the production but there is a growing concern over the adverse effect of use of chemicals on soil productivity, microbial community and environmental quality.

To revive the soil health and microorganisms which support to achieve sustainable

production system, the soil environment need to be made congenial for living of useful microbial population responsible for continuous availability of nutrients from natural sources. Experiencing the adverse effects of synthetic input dependent agriculture, the concept of organic / sustainable / natural farming is gaining momentum. In these systems, the production is based in synergism with nature, which makes systems of unending life, i.e., sustainable. In this context, the experiment was conducted using arbuscularmycorrhizae fungi to check their root colonization ability which in turn will enhance the graft success and survival percentage.

MATERIALS AND METHODS

An investigation was carried out during 2009 in the Department of Agricultural Microbiology, Kittur Rani Channamma College of Horticulture, Arabhavi with three replications in factorial completely randomized design. Extra matricialchlamydospores produced by AM fungi were determined by using wet sieving and decanting method as per Gerdemann and Nicolson (1963). Fifty grams of representative soil samples drawn from each treatment in each replication was suspended in sufficient quantity of water and stirred thoroughly. It was allowed to stand for ten minutes undisturbed before decanting onto the sieves. The suspension was passed through a set of sieves with mesh size 850 μ , 300 μ , 250 μ , 150 μ which were arranged in descending order. The spores collected in 250 μ and 150 μ were transferred to watch glass. Spore count was done using stereomicroscope and expressed as number of chlamydospores per 50 g of soil.

Percent root colonisation was determined using the method as detailed by Phillips and Hayman (1970). To know the per cent AMF (Arbuscular mycorrhiza Fungi) occupancy in

whole root, the whole root were taken and fixed in FAA (Formalin: Acetic acid: Alcohol in the ratio of 5: 5: 90) for 24 hours. The roots were then cleared by autoclaving with 10 per cent KOH for one hour in pressure cooker. The alkalinity due to KOH was neutralised by adding one per cent HCl for five minutes. Then roots were treated with alkaline H₂O₂ treatment for 20 minutes. Staining was done by simmering the roots in 0.05 per cent trypan blue in lactophenol for 10 minutes. Excess stain was decanted and stained roots were stored in lactophenol. The roots were arranged on slides covered and pressed slightly with cover slips for the presence of AMF (Arbuscular Mycorrhiza Fungi) mycelium, vesicles and arbuscles. The average of per cent root colonisation was finally calculated.

Per cent root colonisation =

$$\frac{\text{Number of root bits positive for colonisation}}{\text{Total number of root bits observed}} \times 100$$

RESULTS AND DISCUSSION

The perusal of data (Table 1) on number of chlamydospores per 50 g of soil revealed that cultivated *jamun* rootstocks inoculated with *Glomus fasciculatum* exhibited significantly maximum spore population in the rhizosphere of one month old rootstocks (242.00) and at grafting stage (519.00), while significantly minimum spore population was recorded in uninoculated rootstocks at one month after sowing (23.33) and at grafting stage (91.00).

Wild *jamun* rootstocks inoculated with *Glomus fasciculatum* recorded significantly maximum spore population in the rhizosphere of one month after sowing (175.66) and at grafting stage (421.33), while significantly minimum spore population was recorded in uninoculated rootstocks per 50g of soil at one month after sowing (18.33) and at grafting stage (56.33).

Interaction effect between cultivated and wild *jamun* rootstocks for AM fungal chlamydospores (number/50 g soil) in the rhizosphere of *jamun* rootstocks was found to be significant. Significantly maximum number of chlamydospores was recorded in cultivated *jamun* rootstock inoculated with *Glomus fasciculatum* (242.00) one month after sowing and at grafting stage (519.00), while significantly maximum spore population in the rhizosphere of wild *jamun* rootstocks was recorded in *Glomus fasciculatum* inoculated rootstocks (175.66) one month after sowing which was on par with rootstocks inoculated with *Glomus leptotichum* (167.33) and at grafting stage (421.33). The uninoculated wild *jamun* rootstocks recorded significantly minimum spore population one month after sowing (18.33) and at grafting stage (56.33), where uninoculated cultivated rootstocks (23.33) was on par with uninoculated wild rootstocks one month after sowing.

The data presented in Table 1 revealed that there was no significant result among different type of *jamun* seedlings. However, higher root colonisation was observed in mycorrhiza inoculated seedlings compared to uninoculated seedlings.

Cultivated *jamun* rootstock inoculated with *Glomus fasciculatum* recorded significantly highest colonization of root at one month after sowing (83.25%) and at grafting stage (86.00 %), which was followed by cultivated rootstock inoculated with *Glomus leptotichum* at one month after sowing (80.15 %) and at grafting stage (83.00 %).

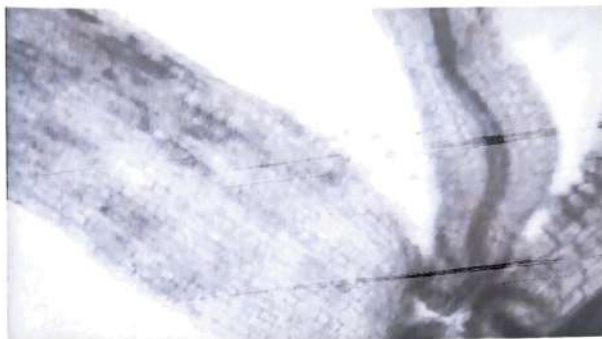
Wild *jamun* rootstocks inoculated with *Glomus fasciculatum* recorded significantly higher root colonisation at one month after sowing (80.00%) and at grafting stage (82.00%) which was on par with rootstock inoculated with *Glomus leptotichum* at one month after sowing (78.20%) and at grafting stage (80.00%). Zero root colonisation was

Table 1. Effect of different AM fungi on chlamydospores and per cent root colonization in cultivated and wild *jamun*

Treatment	Chlamydospores (No./50 g soil)		Per cent root colonization	
	One month after sowing	Grafting stage	One month after sowing	Grafting stage
T1 (Cultivated control)	23.33	91.00	0.00	7.00
T2 (Cultivated+ <i>Glomus fasciculatum</i>)	242.00	519.00	83.25	86.00
T3 (Cultivated+ <i>Glomus leptotichum</i>)	216.33	441.00	80.15	83.00
T4 (Cultivated+ <i>Glomus intraradices</i>)	169.00	296.33	52.25	67.00
T5 (Wild control)	18.33	56.33	0.00	5.50
T6 (Wild+ <i>Glomus fasciculatum</i>)	175.66	421.33	80.00	82.00
T7 (Wild+ <i>Glomus leptotichum</i>)	167.33	359.33	78.20	80.00
T8 (Wild+ <i>Glomus intraradices</i>)	154.66	261.33	65.00	69.00
S.E.m ± A	1.53	1.93	1.14	1.49
B	2.17	2.73	1.61	2.12
AB	3.07	3.87	2.28	2.99
CD (5%) A	4.60	5.76	NS	NS
B	6.50	8.10	4.80	6.32
AB	8.96	11.28	NS	NS
A = Cultivated type B = Wild type AB = Interaction effect				
NS = Non-significant				



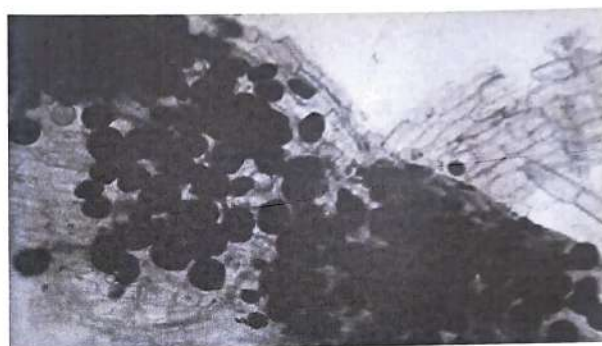
Cultivated control



Wild control



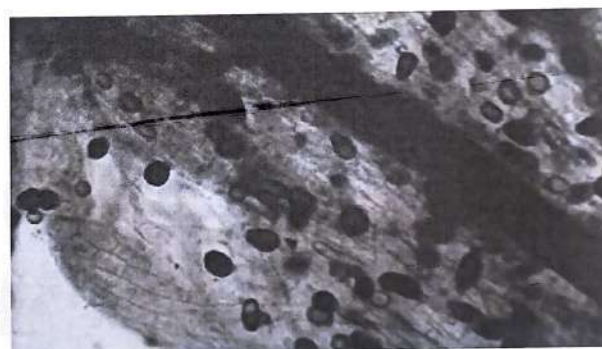
Cultivated + *Glomus fasciculatum*



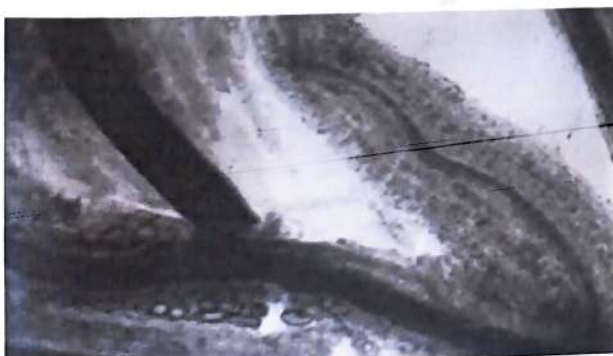
Wild + *Glomus fasciculatum*



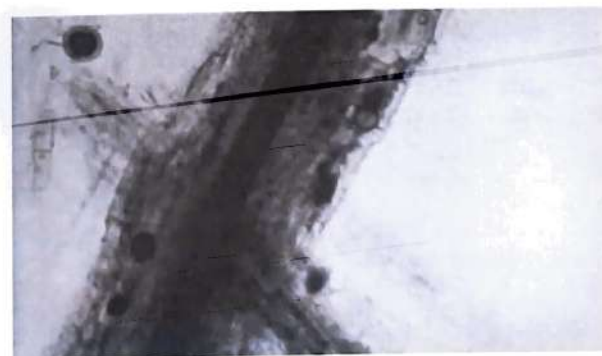
Cultivated + *Glomus leptotichum*



Wild + *Glomus leptotichum*



Cultivated + *Glomus intraradices*



Wild + *Glomus intraradices*

Plate 1. Effect of different AM fungi on per cent root colonization in cultivated and wild jamun

recorded in uninoculated seeds one month after sowing (0.00%) and at grafting stage (5.50%) (Plate 1).

Interaction effect between cultivated and wild jamun rootstocks for per cent root colonisation was found to be non-significant.

In the present investigation *Glomus fasciculatum* registered significantly highest root colonization per cent and number of chlamydospores in cultivated jamun and wild jamun (Table 1). Many workers reported similar results in different fruit crops like citrus [Kleinschmidt and Gerdemann, (1973), Usha *et al.*, (2004) and Venkat *et al.*, (2004)], mango [Santosh (2004) and Bassanagowda (2005)], papaya [Adivappar *et al.*, (2004) and Duragannavar (2005)] and banana [Balakrishna (2003) and Sabarad *et al.*, (2004)] and jamun (Devachandra *et al.*, 2008).

CONCLUSION

From the above investigation it can be concluded that cultivated and wild type jamun rootstocks inoculated with *Glomus fasciculatum* exhibited significantly maximum spore population in the rhizosphere while significantly minimum spore population was recorded in cultivated and wild uninoculated rootstocks. Moreover, cultivated and wild type jamun rootstocks inoculated with *Glomus fasciculatum* recorded significantly higher root colonisation, which will subsequently increase the growth and development of the jamun rootstock.

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Comparison of Selection Indices using Different Weights in Okra [*Abelmoschus esculentus* (L.) Moench]

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ABSTRACT

The data on six different biometrical characters of fifty six genotypes/hybrids of okra were used in the present study and four different weights viz. equal weight, simple correlation coefficients, genotypic correlation and phenotypic correlation as weight were given to different characters to construct selection indices to select the optimum index in okra. The genotypic differences in respect of all the six characters were highly significant. The simple correlation coefficient of the fruit yield per plant had positive and significant correlation with fruits per plant. The results of genotypic correlation observed that the fruit yield per plant had positive and significant correlation with plant height (0.3125), numbers of internodes on main stem (0.2969), fruit length (0.3684), fruits per plant (0.586) and fruit weight (0.5131). The results of phenotypic correlation was found significant and positive for fruit yield with all the characters. The selection index I_{12356} which is combination of fruit yield per plant, plant height, number of internodes on main stem, number of fruits per plant and fruit weight is suggested to select the genotypes for okra fruit yield improvement with equal weight method. Hybrid GAO 5 X Kashi Kranti (P1XP5) was suggested as top ranking genotype in all the weight methods.

Key words : Selection index, Genotype, Equal weight, Genotypic correlation, Phenotypic correlation

INTRODUCTION

Okra [*Abelmoschus esculentus* (L.) Moench] is also known as Lady's finger and it is an annual vegetable crop grown in tropical and subtropical region of the world. India ranks first in the world with annual production of 60,03,000 tones produced from 5,07,000 hectares area with a productivity of 11.8 tones/ha (Anonymous, 2017). The important okra growing states in India are Gujarat, Maharashtra, Andhra Pradesh, Uttar Pradesh, Tamil Nadu, Karnataka, Haryana and Punjab, in which it is cultivated as a *Kharif* as well as summer season crop. In Gujarat, main okra growing districts are Surat,

Vadodara, Junagadh, Surendranagar, Gandhinagar, Banaskantha, Kheda and Anand.

It has been recognized that most rapid improvement in the economic value is expected from selection applied simultaneously to all the characters which determine the economic value of a plant, when appropriate weights are assigned to each character according to their relative economic importance. There is no standard procedure to assign weights to the biometrical characters in selection index. Therefore, an attempt has been made to construct selection index by assigning different weight such as equal weight, simple correlation coefficients,

genotypic correlation coefficients and phenotypic correlation coefficients as weight to different biometrical characters.

MATERIALS AND METHODS

The data on six different biometrical characters of fifty six genotypes/hybrids of okra were collected from Main Vegetable Research Station (MVRS), A.A.U., Anand during *kharif* season of the year 2018 for the present study. The experimental material consisted of ten parents viz. GAO 5, AOL 12-59, AOL 13-144, Phule Prajatika, Kashi Kranti, Arka Abhay, VRO 6, Red One Long, JF 5, JF 108-02; forty five hybrids and one check viz. GJOH 4.

Let us assume that economic value of a plant is determined by different variables and the merit of a plant is H. Then

$$H = a_1G_1 + a_2G_2 + a_3G_3 + \dots + a_nG_n = \sum_{i=1}^n a_iG_i$$

Where,

G_i = Genotypic value of the character

a_i = Weight assigned to the respective characters.

The phenotype (I) is linearly expressed as

$$I = b_1X_1 + b_2X_2 + b_3X_3 + \dots + b_nX_n = \sum_{i=1}^n b_iX_i$$

$$I = b_1X_1 + b_2X_2 + b_3X_3 + \dots + b_nX_n \dots \dots \dots (1)$$

$$H = a_1G_1 + a_2G_2 + a_3G_3 + \dots + a_nG_n \dots \dots \dots (2)$$

These I and H were estimated in such way that regression of I on H was maximized.

$$\text{Thus, } b = [X^{-1}][G][a]$$

Selection index was calculated by substituting value of the character and b_i values in following equation

$$I = b_1X_1 + b_2X_2 + b_3X_3 + \dots + b_nX_n$$

Selection index for all possible combination of six characters can be calculated and the combination which provides the higher relative efficiency is selected. Genetic gain and percent relative efficiency (PRE) were

calculated by using the following formulae. Selection index for single or combination of characters which provides the high PRE is selected

The expected genetic advance is calculated as

$$GA = (Z/P)((\sum a_i b_i G_i) / (\sum b_i b_i p_i)^{1/2})$$

Where Z/P = Selection intensity i.e. 2.06 at 5% level of significance.

Percent Relative efficiency (PRE)

$$PRE = \frac{\text{Genetic gain of selection index}}{\text{Genetic gain of fruit yield}} \times 100$$

RESULTS AND DISCUSSION

Mean, range and coefficient of variation

The results presented in Table 1 revealed that the fruit yield per plant recorded by genotype/hybrid GAO 5 (P1) x Kashi Kranti (P5) was most significant compared to other genotypes. The value of broad sense heritability was 79.76 % which was second highest after fruit weight. The maximum plant height was recorded for the genotype Arka Abhay (P6) X VRO 6 (P7). The maximum numbers of internodes on main stem were recorded for genotype Kashi Kranti (P5) x Arka Abhay (P6). The maximum fruit length was found for the genotype Kashi Kranti (P5) X Arka Abhay (P6). The maximum fruits per plant were recorded for genotype ALO 13-144 (P3) X VRO 6 (P7). The maximum fruit weight was recorded for genotype Phule Prajatika (P4) X Red One Long (P8) and it was statistically at par with GAO 5 (P1), Phule Prajatika (P4), Red One Long (P8), GAO 5 (P1) X Phule Prajatika (P4) and GAO 5 (P1) X VRO 6 (P7). These results are in accordance with Prakash *et al.* (2011) and Nwangburuka *et al.* (2012) in okra.

Simple correlation coefficients

The result of simple correlation coefficients (Table 2) revealed that fruit yield per plant had positive and significant correlation with plant

height (0.2519), number of internodes on main stem (0.2831), fruit length (0.2011), fruits per plant (0.7471) and fruit weight (0.6794).

It was also found that plant height had significant and positive correlation with number of internodes on main stem (0.4328), fruit length (0.3995), fruits per plant (0.1816) and fruit weight (0.1874). It was also found that number of internodes on main stem had significant and positive correlation with fruits per plant (0.4161). Fruit length had significant and positive correlation with fruit weight (0.3163).

Positive and significant correlation between fruit yield and fruit weight observed in this study was also reported by Akinyele and Osekita (2006), Reddy *et al.* (2013) and Balai *et al.* (2014). Also, same result in potato by Lamboro *et al.* (2014). The positive and significant correlation between fruit yield and number of internodes on main stem and fruit length were observed by Mihretu Yonas *et al.* (2014), Kumar and Reddy (2016) and Dwivedi and Sharma (2017) in okra.

Genotypic and Phenotypic correlation coefficients

The correlation coefficients between fruit yield per plant and its component traits among themselves were estimated at genotypic and phenotypic levels. The results of genotypic and phenotypic correlation coefficients between fruit yield per plant and its components are given in Table 3. Positive and significant genotypic correlation between fruit yield with all the characters were observed. Fruits per plant had the highest genotypic correlation with fruit yield followed by fruit weight. Similar trend was also observed for phenotypic correlation with yield. Plant height had also significant genotypic correlation with fruit length (0.9582), number of internodes on main stem (0.6712) and fruit weight (0.2138). Significant and positive phenotypic correlation of fruit yield was found with all the

character. Plant height was found phenotypically significant with all the character except fruit weight (0.1107). The results of remaining characters revealed that positive and significant correlation of number of internodes on main stem with fruit length and fruits per plant, while fruit length with fruit weight was also found significant and positive at genotypic and phenotypic level.

Positive and significant genotypic and phenotypic correlation between fruit yield and plant height was observed by Nwangburuka *et al.* (2012), Duggi *et al.* (2013). Similarly positive and significant genotypic and phenotypic association of fruit yield with number of internodes on main stem, fruit length, number of fruits per plant and fruit weight were observed by Reddy *et al.* (2013) and Balai *et al.* (2014) in okra.

Selection indices using different weights

Selection indices were worked out taking six biometrical characters and were constructed taking all possible combinations of the characters. Total sixty three selection indices were constructed using equal weight (W_1), simple correlation coefficient (W_2), genotypic correlation coefficients (W_3) and phenotypic correlation coefficients (W_4) for all characters.

Expected genetic gain and relative efficiency (%) for single character

The selection indices were constructed for single character separately. Total six selection indices were constructed for each weight methods (W_1 , W_2 , W_3 and W_4). The genetic gain in okra fruit yield per plant (63.7069) with equal weight was considered as a base in all single as well as combinations of characters. Relative to this, the efficiency was worked out for selection of single character for different methods.

Per cent relative efficiency (PRE) for selection index of biometrical characters ranged from 1.12 to 100.00, 3.17 to 100.00, 0.33 to 100.00, 0.32 to 100.00 for W_1 , W_2 , W_3 and W_4 respectively. The highest PRE were observed

for fruit yield per plant in equal weight methods. The lowest PRE were observed for number of internodes on main stem in all weight methods. In general, the percent relative efficiency was higher in equal weight method as compared to other methods. This result in accordance with Chattopadhyay et al. (2011), Bashar et al. (2015) in brinjal, Premalakshmi et al. (2014) and Sherpa et al. (2014) in tomato also found in equal weight is dominating method same as Silva et al. (2018) found the same result in potato. Also fruit yield had 100 per cent relative efficiency were found in equal weight method, genotypic correlation and phenotypic correlation as weight methods.

Expected genetic gain and relative efficiency (%) for combination of two characters

All possible combinations of two characters were used to construct selection indices using different weights (W_1 to W_4). Total fifteen selection indices in each weight method were constructed. The genetic gain for fruit yield (single character) with equal weight method (63.7069) was considered as base and the efficiency was worked out for all selection indices of all possible combinations of six characters for different weights. PRE ranged between 3.13 (number of internodes on main stem and fruit length) to 109.06 (fruit yield and plant height) for equal weight method, 0.74 (number of internodes on main stem and fruit length) to 106.28 (fruit yield and plant height) for simple correlation coefficients weight method, 1.06 (number of internodes on main stem and fruit length) to 107.18 (fruit yield and plant height) for genotypic correlation weight method, 0.76 (number of internodes on main stem and fruit length) to 106.96 (fruit yield and plant height) for phenotypic correlation weight method. In general, it was observed that the per cent relative efficiency was the highest in equal weight method (W_1) followed by simple correlation coefficients weight method (W_2), genotypic correlation weight method (W_3),

phenotypic correlation weight method (W_4).

The highest PRE were observed for fruit yield and plant height combination in all weight methods. The lowest PRE was observed for number of internodes on main stem and fruit length combination in all weight method.

Expected genetic gain and relative efficiency (%) for combination of three characters

Out of six biometrical characters all possible combinations of three characters were taken at a time to construct selection indices using different weights. Total twenty indices consisting different combinations of characters were constructed. The genetic gain for fruit yield per plant (63.7069) alone with equal weight method was used as base to workout per cent relative efficiency for all selection indices. Per cent relative efficiency ranged from 5.77 (number of internodes on main stem, fruit length and fruit weight) to 122.13 (fruit yield, plant height and number of internodes on main stem) for equal weight method. The ranged from 2.95 (number of internodes on main stem, fruit length and fruit weight) to 109.85 (fruit yield, plant height and number of internodes on main stem) for simple correlation weight method. The ranged from 2.58 (number of internodes on main stem, fruit length and fruit weight) to 110.75 (fruit yield, plant height and number of internodes on main stem) for genotypic correlation weight method, while for phenotypic correlation weight method, ranged from 2.03 (number of internodes on main stem, fruit length and fruit weight) to 110.52 (fruit yield, plant height and number of internodes on main stem).

Among all possible combinations, the highest per cent relative efficiency was observed for combination of fruit yield per plant, plant height, number of internodes on main stem (I_{123}) with W_1 , W_2 , W_3 , W_4 weight method.

Expected genetic gain and relative efficiency (%) for combination of four characters

Out of six biometrical characters any four were taken at a time to construct selection indices using different weights. There were fifteen different possible combinations of four characters and were used to determine selection indices with different weights. Thus, 60 indices were constructed. The genetic gain for fruit yield per plant with equal weight method (63.7069) was considered as 100 per cent relative efficiency. Relative to this genetic gain, the efficiencies were worked out for selection index of all possible combinations of four characters for all the four weight methods (W_1 to W_4). The results revealed that PRE ranged from 8.28 (I_{3456}) [number of internodes on main stem, fruit length, fruits per plant and fruit weight] to 124.91 (I_{1235}) [fruit yield, plant height, number of internodes on main stem, fruits per plant] for equal weight method (W_1), 4.95 (I_{3456}) [number of internodes on main stem, fruit length, fruits per plant and fruit weight] to 111.86 (I_{1235}) [fruit yield, plant height, number of internodes on main stem, fruits per plant] for (W_2), 4.11 (I_{3456}) [number of internodes on main stem, fruit length, fruits per plant and fruit weight] to 112.36 (I_{1235}) [fruit yield, plant height, number of internodes on main stem, fruits per plant] for genotypic correlation weight method (W_3), 3.54 (I_{3456}) [number of internodes on main stem, fruit length, fruits per plant and fruit weight] to 112.02 (I_{1235}) [fruit yield, plant height, number of internodes on main stem, fruits per plant] for phenotypic correlation weight method (W_4).

It was reported that the higher per cent relative efficiency was observed in equal method as compared to rest of the weight methods as the numerical value of weight was higher as compared to all method. Index (I_{1235}) gave highest PRE in equal weight (124.91), genotypic correlation as weight (112.36) phenotypic correlation as weight (112.02).

Expected genetic gain and relative efficiency (%) for five characters

Out of six characters all possible combinations of five different characters were taken at a time to construct selection indices using different weight methods. Six different indices were constructed for each weight methods so total twenty four indices were constructed using this method. The genetic gain for fruit yield per plant (63.7069) alone with equal weight method was used as base to workout per cent relative efficiency for all the selection indices. Per cent relative efficiency ranged from 32.73 (I_{23456}) [plant height, number of internodes on main stem, fruit length, fruits per plant and fruit weight] to 127.13 (I_{12356}) [fruit yield, plant height, number of internodes on main stem, fruits per plant and fruit weight] for equal weight method, 9.87 (I_{23456}) [plant height, number of internodes on main stem, fruit length, fruits per plant and fruit weight] to 113.43 (I_{12356}) [fruit yield, plant height, number of internodes on main stem, fruits per plant and fruit weight] for simple correlation weight method, 11.07 (I_{23456}) [plant height, number of internodes on main stem, fruit length, fruits per plant and fruit weight] to 113.55 (I_{12356}) [fruit yield, plant height, number of internodes on main stem, fruits per plant and fruit weight] for genotypic correlation weight method, 10.13 (I_{23456}) [plant height, number of internodes on main stem, fruit length, fruits per plant and fruit weight] to 113.02 (I_{12356}) [fruit yield, plant height, number of internodes on main stem, fruits per plant and fruit weight] for phenotypic correlation weight method.

The highest PRE was observed in the selection index (I_{12356}) consisting fruit yield, plant height, number of internodes on main stem, fruits per plant and fruit weight in all weight methods as compared to different combinations of biometrical characters within the respective weight method. Among different weight methods equal weight (W_1) had highest PRE followed by genotypic

Table 1 : Mean, range and coefficient of variation for different characters of okra

Parameters	Yield (g)	Plant Height (cm)	No. of Internodes	Fruit length (cm)	No. Fruits per Plant	Fruit Weight (g)
Mean	278.18	141.33	19.31	14.15	20.15	13.90
Range	206.33-399.99	98.73-168.40	16.53-21.87	11.71-16.01	16.60-24.07	11.54-17.03
S.E.m. $\pm$	16.93	8.70	0.90	0.52	1.03	0.46
CD at 5%	47.45	24.38	2.53	1.45	2.88	1.29
CV (%)	10.54	10.66	8.08	6.32	8.82	5.75
Broad sense heritability	79.76	59.82	44.57	66.96	71.73	86.69

Table 2 : Simple correlation coefficients between fruit yield and different characters of okra genotypes

CHARACTERS	FY	PH	NOIMS	FL	FP	FW
FY	1.0000	-	-	-	-	-
PH	0.2519*	1.0000	-	-	-	-
NOIMS	0.2831*	0.4328*	1.0000	-	-	-
FL	0.2011*	0.3995*	0.1391	1.0000	-	-
FP	0.7471*	0.1816*	0.4161*	0.0049	1.0000	-
FW	0.6794*	0.1874*	-0.0370	0.3163*	0.0277	1.0000

*, ** significant at 0.05 and 0.01 level of significance, respectively

Where, **FY**: Fruit yield per Plant, **PH**: Plant Height, **NOIMS**: Number of Internodes on Main Stem, **FL**: Fruit Length, **FP**: Fruits per Plant, **FW**: Fruit Weight.

Table 3 : Genotypic and Phenotypic correlation coefficients between different characters in okra

CHARACTERS	PARAMETERS	FY	PH	NOIMS	FL	FP	FW
FY	rg	1.0000	0.3125*	0.2969*	0.3684*	0.5860*	0.5131*
	rp	1.0000	0.2978*	0.2894*	0.2061*	0.5395*	0.4281*
PH	rg	-	1.0000	0.6712*	0.9582*	0.1298	0.2138*
	rp	-	1.0000	0.4393*	0.3967*	0.1720*	0.1107
NOIMS	rg	-	-	1.0000	0.6053*	0.4745*	-0.0060
	rp	-	-	1.0000	0.1332	0.4126*	-0.0270
FL	rg	-	-	-	1.0000	0.0866	0.3873*
	rp	-	-	-	1.0000	0.0638	0.2399*
FP	rg	-	-	-	-	1.0000	0.0658
	rp	-	-	-	-	1.0000	0.1375
FW	rg	-	-	-	-	-	1.0000
	rp	-	-	-	-	-	1.0000

r_g = genotypic correlation r_p = phenotypic correlation

*, ** significant at 0.05 and 0.01 level of significance, respectively

Where, **FY**: Fruit Yield per Plant, **PH**: Plant Height, **NOIMS**: Number of Internodes on Main Stem, **FL**: Fruit Length, **FP**: Fruits per Plant, **FW**: Fruit Weight.

Table 4: Top three ranking selection indices in different weight methods with okra fruit yield per plant

Combinations	Top Rank	Equal Wt. [W ₁]	Corr.Wt. [W ₂]	GCWt. [W ₃]	PCWt. [W ₄]
Combinations of two characters	1	I ₁₂ (109.06)	I ₁₂ (106.28)	I ₁₂ (107.18)	I ₁₂ (106.96)
	2	I ₁₆ (103.38)	I ₁₆ (102.61)	I ₁₆ (102.22)	I ₁₆ (102.02)
	3	I ₁₅ (102.78)	I ₁₅ (102.07)	I ₁₅ (101.62)	I ₁₅ (101.49)
Combinations of three characters	1	I ₁₂₃ (122.13)	I ₁₂₃ (109.85)	I ₁₂₃ (110.75)	I ₁₂₃ (110.52)
	2	I ₁₂₅ (121.15)	I ₁₂₅ (108.51)	I ₁₂₅ (109.00)	I ₁₂₅ (108.66)
	3	I ₁₂₄ (120.48)	I ₁₂₄ (108.50)	I ₁₂₄ (109.00)	I ₁₂₄ (108.58)
Combinations of four characters	1	I ₁₂₃₅ (124.91)	I ₁₂₃₅ (111.86)	I ₁₂₃₅ (112.36)	I ₁₂₃₅ (112.02)
	2	I ₁₂₃₆ (124.43)	I ₁₂₃₆ (111.47)	I ₁₂₃₆ (111.99)	I ₁₂₃₆ (111.57)
	3	I ₁₂₃₄ (124.18)	I ₁₂₃₄ (110.54)	I ₁₂₃₄ (111.21)	I ₁₂₃₄ (110.79)
Combinations of five characters	1	I ₁₂₃₅₆ (127.13)	I ₁₂₃₅₆ (113.43)	I ₁₂₃₅₆ (113.55)	I ₁₂₃₅₆ (113.02)
	2	I ₁₂₃₄₅ (126.83)	I ₁₂₃₄₅ (112.10)	I ₁₂₃₄₅ (112.82)	I ₁₂₃₄₅ (112.28)
	3	I ₁₂₃₄₆ (126.47)	I ₁₂₃₄₆ (111.71)	I ₁₂₃₄₆ (112.45)	I ₁₂₃₄₆ (111.83)

Parenthesis value indicates per cent relative efficiency (PRE)

Table 5: Rank correlations between different weight methods based on best selection index of respective weight methods including okra fruit yield per plant

Weight	Equal wt.	Corr. Wt.	GC Wt.	PC Wt.
Equal Wt.	1.000**	0.999**	0.999**	0.999**
Corr. Wt.	-	1.000	1.000**	1.000**
GCWt.	-	-	1.000	1.000**
PCWt.	-	-	-	1.000

*, ** significant at 0.05 and 0.01 level of significance, respectively; n = 56

correlation (W_3), Simple correlation (W_2), phenotypic correlation (W_4) as weight to different characters. Also, the selection index (I_{12356}) gave higher genetic gain in all weight methods, which is combination of fruit yield, plant height, number of internodes on main stem, fruits per plant and fruit weight.

Expected genetic gain and relative efficiency (%) for six characters

Combinations of all six biometrical characters were used to construct selection indices using different weights. The genetic gain for fruit yield alone (63.7069) with equal weight was considered as 100 PRE. Per cent relative efficiencies were 129.06, 113.67, 114.01 and 113.27, for equal weight, simple correlation, genotypic correlation and phenotypic correlation taken as weight respectively. Higher percent relative efficiency was observed in equal weight method as compared to rest of the weight methods.

Comparison of three ranking selection indices

The results presented in table 4 showed that the selection index (I_{12356}) which was combination of fruit yield per plant, plant height, number of internodes on main stem, fruits per plant and fruit weight possessed highest PRE for all the weight method. Thus, based on this results taking of equal weight method the per cent relative efficiency was highest and one can use equal weight (W_1) of characters for construction of selection indices to achieve higher genetic gain followed by simple correlation (W_2) genotypic correlation (W_3), phenotypic correlation (W_4).

Selection score with rank for fifty six genotypes based on different indices

The index score values were worked out for all four weight methods for all genotypes in respect of highest PRE given by different combination of characters. The results (Table 4) indicated that in general PRE with equal

weight was higher than rest of the weights in all combinations of indices. The rank correlation among different methods for selection score values (Table 5) were positive and highly significant indicating agreement with all methods.

CONCLUSION

The selection index $I_{12356} = 0.793 X_1 + 1.009 X_2 - 5.443 X_3 - 0.948 X_5 + 1.206 X_6$ Where, X_1 = fruit yield per plant (g), X_2 = plant height (cm), X_3 = number of internodes on main stem, X_5 = number of fruits per plant and X_6 = fruit weight (g) was suggested to select the genotypes for okra fruit yield improvement with equal weight method. Thus, based on these results taking equal weight method the per cent relative efficiency was the highest and one can use equal weight (W_1) of characters for construction of selection indices to achieve higher genetic gain followed by simple correlation (W_2) genotypic correlation (W_3) and phenotypic correlation (W_4). Hybrid GAO 5 X Kashi Kranti (P1 X P5) was suggested as top ranking genotype in all the weight methods.

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Association between Selected Attributes of Drip Owners with the Socio-economic Impact of Drip Irrigation

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ABSTRACT

The present study was designed to know the association between selected attributes of drip owners and the socio-economic impact of drip irrigation. The study was carried out in three talukas of Sabarkantha district. Five villages were randomly selected from each taluka and 10 drip owners were randomly selected from each village, thus the sample consisted of 150 respondents. Appropriate statistical methods were used for analysing the collected data. It can be concluded from the study that among the selected ten attributes, six attributes viz., education, irrigation potentiality, cropping intensity, economic motivation, attitude and extension contact was positively and significantly and age was negatively and significantly correlated with socio-economic impact of drip irrigation. While, three attributes viz., social participation, area under DIS and annual income had positive but non-significant relationship with socio-economic impact of drip irrigation.

Keywords: Association, Socio-economic impact, Drip owners

INTRODUCTION

Agriculture forms the main base for Indian socio-economic development. However, the agricultural production and productivity is yet to be boosted to meet the need of the population. For increasing the agricultural production, the importance of irrigation is fully realized, but the proper use of water is seldom practiced in our country. The regularized and controlled irrigation increases crop production, reduce water cost, conserves soil, covers more area under irrigation and brings prosperity at home.

Rainfall is irregular and uneven in many parts of the country. Gujarat is also facing this situation. Shortage of water has become one of the main problems in Gujarat for the farmers. Therefore, efficient use of available water has become extremely important,

which can be done through drip irrigation system.

In Gujarat state, Saurashtra, Bhal and North Gujarat regions are considered as dry farming areas. In these regions, the availability of water for irrigation is extremely scarce and irregular. Generally, farmers look for a method of irrigation, which is most efficient with less water, labour, fertilizer and power requirements. Among the irrigation methods the drip irrigation system, is the advanced method of irrigation to overcome the various problems of water losses and other problems such as labour, money and water management. This method is rapidly gaining importance in the area where water is scarce and high value crops are produced.

Drip irrigation is an effective and efficient method of providing water directly to the root zone of plant. Drip irrigation represents one of the fastest expanding technologies in modern

irrigation agriculture. Water is applied at low rate under pressure to keep soil moisture within the desired range for plant growth. This system saves 40 to 70 per cent of irrigation water. A well drip irrigation system also promotes the utilization of fertilizer, pesticides and other water soluble chemicals along with irrigation water. Research studies conducted worldwide have shown that this method leads not only to appreciable water saving, but also achieving high crop yield as compared to surface irrigation methods. This system is adaptable to most of the crops, under most of the soils and particularly suited to soil under condition of water scarcity. Crops like sugarcane, fruits, vegetables, oilseeds and cotton are ideally suited crops for drip irrigation.

The present study was conducted with the following objectives:

1. To study the selected attributes of the drip owners
2. To assess the impact of drip irrigation system on socio-economic status of the drip owners
3. To ascertain the association between selected attributes of drip owners and their socio-economic impact of drip irrigation system

MATERIALS AND METHODS

The present study was confirmed to "Ex-Post Facto" research design as the independent variables had already operated in the study area. A multistage random sampling technique was used for selection of talukas, villages and respondents. Sabarkantha district was selected purposively. Among the different talukas of Sabarkantha district Idar, Vadali and Himmatnagar talukas were randomly selected. Five villages were selected from each selected taluka on the

basis of highest number of drip owners. Thus, total 15 villages having highest number of drip owners were selected. A list of farmers who installed drip irrigation system on their farm was prepared for each selected village. Ten respondents from each village were selected by using random sampling techniques making a sample of 150 respondents. Socio-economic impact of drip owners was considered as dependent variable in the study. The data were collected with the help of structured interview schedule. The collected data were coded, classified, tabulated and analysed by using the statistical tools such as frequency, per cent, mean, standard deviation and correlation coefficient.

RESULTS AND DISCUSSION

A. Selected attributes of drip owners

It was beyond the scope of the present study to include all important characteristics of the respondents. However, some important characteristics of farmers were selected and classified into four groups viz., personal, agro-economic, psychological and communication attributes. The findings of these attributes have been presented in the following Table 1.

The data presented in Table.1 indicates that more than half (54.37 per cent) of the drip owners were from the middle age group. The 87.33 per cent of the drip owners were possessed up to post-graduate level of education whereas, 12.67 per cent of drip owners were illiterate. The 65.33 per cent of the drip owners were member of one organization. Slightly more than two fifth of drip owners (42.00 per cent) had 1.00 to 2.00 ha area under drip irrigation system. Nearly half of the drip owners (47.33 per cent) were having medium level of irrigation potentiality. Whereas, 50.67 per cent of the drip owners

Table: 1. Selected attributes of drip owners (n=150)

No.	Selected attributes of drip owners		Frequency	Percent
(A) Personal Attributes				
1	Age	Young age (up to 35 years)	37	24.67
		Middle age (36 to 50 years)	82	54.67
		Old age (above 50 years)	31	20.66
2	Education	Illiterate	19	12.67
		Can read only	06	04.00
		Can read and write	28	18.66
		Primary	27	18.00
		Middle	37	24.67
		High	24	16.00
		Post-Graduate and above	09	06.00
3	Social participation	No membership	15	10.00
		Member of one organization	98	65.33
		Member of more than one organizations	28	18.67
		Office holders	09	06.00
(B) Agro-economic attributes				
4	Area under DIS	Up to 1.00 ha	19	12.67
		1.01ha to 2.00 ha	63	42.00
		2.01 ha to 3.00 ha	39	26.00
		Above 3.01 ha	29	19.33
5	Irrigation potentiality	Low (Up to 49.40 score)	43	28.67
		Medium (Between 49.40-90.00 score)	71	47.33
		High (Above 90.00 score)	36	24.00
		Mean=69.70	S.D. = 20.30	
6	Cropping intensity	Low (Up to 208.35 score)	38	25.33
		Medium (Between 208.35-297.65 score)	76	50.67
		High (Above 297.65 score)	36	24.00
		Mean=253	S.D. = 44.65	
7	Annual income	Low (Up to ₹160039)	16	10.67
		Medium (Between ₹160039 - ₹609269)	127	84.66
		High (Above ₹ 609269)	07	04.67
		Mean=384654	S.D. =224615	
(C) Psychological attributes				
8	Economic motivation	Low (Up to 23.50 score)	28	18.67
		Medium (Between 23.50-29.18 score)	82	54.67
		High (Above 29.18 score)	40	26.66
		Mean=26.34	S.D. = 2.84	
9	Attitude towards DIS	Less favourable (Up to 105.40 score)	42	28.00
		Moderately favourable (Between 105.40-140.20 score)	87	58.00
		Highly favourable (Above 140.20 score)	21	14.00
		Mean=122.80	S.D.=17.40	
(D) Communicational attributes				
10	Extension contact	Low (Up to 1.50 score)	21	14.00
		Medium (Between 1.50-3.60 score)	91	60.67
		High (Above 3.60 score)	38	25.33
		Mean=2.55	S.D.=1.05	

possess medium level of cropping intensity and 84.66 per cent of the drip owners had medium level of annual income. More than half of the drip owners (54.67 per cent) possess medium to high level of economic motivation. While, 58.00 per cent had moderately favourable attitude towards drip irrigation system. Slightly more than three fifth of the drip owners (60.67 per cent) had medium level of extension contact.

B. Impact of drip irrigation system on socio-economic status of the drip owners

Impact is the major component in this study which is the resultant changes occurred

Table 2: Distribution of drip owners according to their socio-economic impact of DIS (n = 150)

Sr. No.	Impact of DIS	Frequency	Per cent
1	Low (Up to 19.80 score)	25	16.67
2	Medium (Between 19.80-25.40 score)	94	62.67
3	High (Above 25.40 score)	31	20.66
Total :		150	100.00
Mean = 22.60		S.D. = 2.80	

The data in Table 2 indicated that slightly more than three fifth (62.67 per cent) of the drip owners were having medium level of socio-economic impact, followed by 20.66 and 16.67 per cent of them had high and low level of socio-economic impact, respectively.

C. Association between selected attributes of drip owners and the socio-economic impact of drip irrigation system

The correlation coefficient 'r' was worked out to know the association between independent and dependent variables. The correlation coefficient was calculated for socio-economic impact of drip irrigation with ten independent variables which were grouped into (i) personal attributes, (ii) agro-economic attributes, (iii) psychological and (iv) communicational attribute. The results in this regards are discussed under following sub-titles and presented in Table 3.

among the drip owners due to adoption of drip irrigation system. It is assessment of changes in terms of socio-economic aspects of drip owners. The resultant changes that occurred after adoption of drip irrigation system viz., change in self-sufficiency, change in social status, saving in water, fertilizer cost, plant protection cost, weed control expenses, saving in labour utilisation, energy cost, increase in crop production, improving quality of produce and early maturity of crop were considered as major aspect of socio-economic impact. The information in this regard was collected and classified in to three levels viz., low, medium and high. The data are presented in Table 2.

The education, irrigation potentiality, cropping intensity, economic motivation, attitude and extension contact were positively and significantly and age was negatively and significantly correlated with socio-economic impact of drip irrigation system. Social participation, area under DIS and annual income had positive and non-significant relationship with socio-economic impact of drip irrigation system.

CONCLUSION

The regularized and controlled irrigation increases crop production, reduce water cost, conserves soil, covers more area under irrigation and brings prosperity at home. It can be concluded from the study that 62.67 per cent of the drip owners had medium level of socio-economic impact while 20.66 per cent had high level of socio-economic impact.

Table 3 : Association between selected attributes of drip owners and the socio-economic impact of DIS (n=150)

Sr. No.	Independent variables	Correlation coefficient ('r' value)
[I]	Personal variables :	
	(1) Age	-0.389**
	(2) Education	0.554**
	(3) Social participation	0.089NS
[II]	Agro-economic variables :	
	(1) Area under DIS	0.112NS
	(2) Irrigation potentiality	0.279**
	(3) Cropping intensity	0.231**
	(4) Annual income	0.138NS
[III]	Psychological variables :	
	(1) Economic motivation	0.412**
	(2) Attitude towards DIS	0.458**
[IV]	Communication variables :	
	(1) Extension contact	0.468**

** = Significant at 1% level; * = Significant at 5% level; NS = Not significant

While in case of association, education, irrigation potentiality, cropping intensity, economic motivation, attitude and extension contact were positively and significantly correlated with socio-economic impact of drip irrigation system. On the other hand age was negatively and significantly correlated with socio-economic impact of drip irrigation system where as social participation, area under DIS and annual income had positive and non-significant relationship with socio-economic impact of drip irrigation system.

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Determination of Selected Physical Properties of Vegetable Seedlings for Development of Vegetable Transplanter

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ABSTRACT

The physical properties of vegetable seedlings are important for the design or development of vegetable transplanters. The transplanting of vegetable seedlings is generally accomplished through manual, semi-automatic or fully automatic transplanters. The selected physical parameters like, plant height, plant weight, stem diameter and plant canopy of the tomato and chilli seedlings were measured as per the age of the seedlings (4, 5 and 6 weeks). The observed average height of seedlings was 115, 125.4 and 133 mm (Chilli); and 117, 122 and 135.60 mm (Tomato) for 4, 5 and 6 weeks old seedlings, respectively. The average weight of seedlings was determined 12.38, 15.34 and 16.64 g (Chilli); and 13.64, 16.82 and 19.86 g (Tomato) for 4, 5 and 6 weeks old seedlings, respectively. The average diameters of stems were 1.29, 1.38 and 1.41 mm (Chilli); and 2.22, 2.58 and 3.39 mm (Tomato) for 4, 5 and 6 weeks old seedlings, respectively. The average plant canopies were 97.2, 115.2 and 129.2 mm (Chilli); and 74.60, 88.20 and 119.80 mm (Tomato) for 4, 5 and 6 weeks old seedlings, respectively.

Keywords : Physical properties, Seedlings, Tomato, Chilli, Design, Vegetable transplanter

INTRODUCTION

The importance of vegetables in human nutrition is well known. They are the cheapest natural nutritive food sources and the only source of protective nutrients such as minerals and vitamins. India is the world's second largest vegetable producer, from 2004-2005 to 2018-2019 and the cultivated area for vegetable production increased gradually, rising from 6.74 mha to 10.10 mha (Khadatkaret.al,2020). India produces and consumes the most vegetables, followed by China. Vegetable production covers

approximately 8.50 million ha, yielding nearly 188.28 million tonnes and accounting for approximately 15% of global vegetable production (Nage *et al.*, 2022).

Due to increase in labour wages and labour shortage during the peak season, transplanting of vegetables has become more cost intensive unit operation. Another reason is that, seedling grown in nurseries and transplanting them into another field almost done by manually and requires 40% of total cultivation hours (Khadatkar *et.al*, 2018). Mechanization in transplanting means reducing the labour demand during cultivation

with the minimum damage to seedling and attaining the maximum efficiency in unit operations.

The mechanization in vegetable transplanting is important for efficient operation and increased production (Turbatmath *et.al*, 2010). Day by day the demand of the vegetables is increasing due to increasing population and health consciousness, to fulfill the above demand and export the good quality of vegetables in a time bound system the mechanization of the Indian farms is inevitable. For the mechanization in Indian farms the manual and semi-automatic vegetable transplanters are very much economical with respect to operating and servicing cost. The field capacity and accuracy are higher in automatic transplanter but having high initial cost, its complicated mechanism and servicing facility makes it uneconomical in Indian farms (Pandirwaret al., 2015).

MATERIAL AND METHODS

As suggested by Mohsenin (1986) and Thorat *et al* (2017), for easy passage of plug seedlings and its subsequent vertical placement along with the movement from the jaw is influenced by the physical properties seedlings, such as plant height, plant weight, stem thickness and plant canopy. From this point of view following properties was measured as discussed below.

Plant height—The plant height is necessary for the design and development of the seedling carrying tube and dropping jaws. The seedlings were gently pulled from the plug tray and length of the plant (tip of the leaf to the end of stem *i.e.* excluding roots) was measured by scale having least count of 1 mm as shown in figure 3.1, as suggested by Mohsenin (1986). three such observations were recorded for every age (*i.e.* 4, 5 and 6

weeks of seedlings).

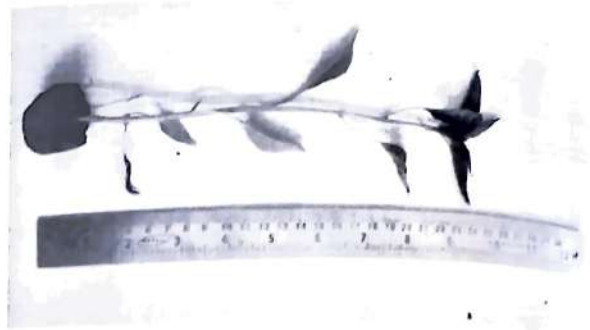


Fig. 3.1 Measuring plant height by steel ruler

Plant weight—Plant weight is very important for the gravitational speed of the seedlings drop from a specific height. Weight of plant was measured using weighing balance having least count 0.5 g as shown in figure 2, as suggested by Mohsenin (1986). Three such observations were recorded for every age (*i.e.* 4, 5 and 6 weeks of seedlings).

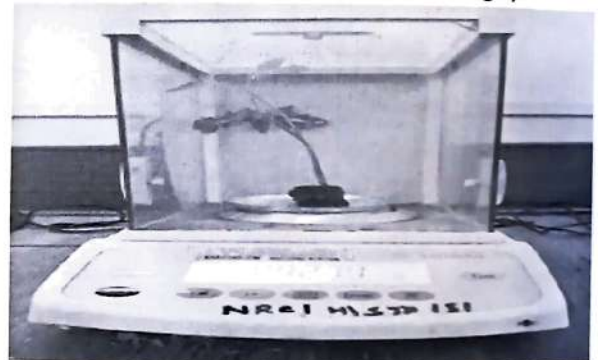


Figure 2 Weighing balance for measuring the plant weight.

Plant stem diameter: Stem diameter that represents the thickness of vegetable seedlings. The measurements were done at



Figure 3 Measuring the plant stem diameter by Vernier Caliper

three positions on the stem i.e. Top, middle and bottom measured by vernier caliper having least count of 0.02 mm as shown in figure 3. as suggested by Mohsenin (1986). Three such observations were recorded for every age (i.e. 4, 5 and 6 weeks of seedlings) were taken.

Plant Canopy-The size of the canopy of plug seedlings was specified by the critical canopy diameter and is define das the minimum inner diameter of a circular pipe through which a healthy plug seedling dropped (Thor at, 2017). Plant canopy of randomly selected vegetable seedlings (Chilli and tomato) was measured by vernier caliper having least count of 0.02 mm as shown in figure 4 as

suggested by Mohsenin (1986). Three such observations were recorded for every age (i.e. 4, 5 and 6 weeks of seedlings).



Fig. 4 Measuring the plant canopy by vernier caliper

RESULTS AND DISCUSSION

The physical properties of the vegetable seedlings are required in design and selection of different components of machine. Relevant properties namely weight, height, stem thickness, plant canopy were measured and are summarized in Table 1 to Table 4

Weight of seedlings

The weight of chilli and tomato seedlings is given in Table 1 . The average weight of seedlings was 12.38, 15.34 and 16.64 g (Chilli); and 13.64, 16.82 and 19.86 g (Tomato) for 4, 5 and 6 weeks old seedlings, respectively. The weight of seedlings increases with age.

Table 1 Average weight of Chilli and Tomato seedlings

Sr. No.	Age of seedlings	Weight of Chilli seedling	Weight of Tomato seedling
1	4 weeks of seedlings	12.38	13.64
2	5 weeks of seedlings	15.34	16.82
3	6 weeks of seedlings	16.61	19.86

Height of seedlings

The data pertaining to the height of the seedlings (Chilli and Tomato) are given in Table 2. The average height of seedlings was

115, 125.4 and 133 mm (Chilli); and 117, 122 and 135.60 mm (Tomato) for 4, 5 and 6 weeks old seedlings, respectively.

Table 2 Average height of Chilli and Tomato seedlings

Sr. No.	Age of seedlings	Height of Chilli seedling	Height of Tomato seedling
1	4 weeks of seedlings	115	117
2	5 weeks of seedlings	125.4	122
3	6 weeks of seedlings	133	135.60

Stem thickness

The stem thicknesses are given in table 3. The average diameters of stems were 1.29, 1.38 and 1.41 mm (Chilli); and 2.22, 2.58 and 3.39 mm (Tomato) for 4, 5 and 6 weeks old

seedlings, respectively. The results show that stem thickness of vegetable seedling increases with increase in age of seedlings. The metering mechanism and feeding cups was designed based on seedling dimensions.

Table 3 Average stem thickness of Chilli and Tomato seedlings, mm

Sr. No.	Age of seedlings	Stem thickness of Chilli seedling	Stem thickness of Tomato seedling
1	4 weeks of seedlings	1.29	2.22
2	5 weeks of seedlings	1.38	2.58
3	6 weeks of seedlings	1.41	3.39

Plant canopy

The plant canopies are given in table 4. The average plant canopies were 97.2, 115.2 and 129.2 mm (Chilli); and 74.60, 88.20 and

119.80 mm (Tomato) for 4, 5 and 6 weeks old seedlings, respectively. The results show that plant canopy of vegetable seedling increases with increase in age of seedlings.

Table 4 Average plant canopy of Chilli and Tomato seedlings

Sr. No.	Age of seedlings	Plant canopy of Chilli seedling	Plant canopy of Tomato seedling
1	4 weeks of seedlings	97.2	74.60
2	5 weeks of seedlings	115.2	88.20
3	6 weeks of seedlings	129.2	119.80

CONCLUSION

From the above study it concludes that the physical parameters such as plant weight, plant height, stem thickness and plant canopy of the vegetable seedlings show the vast impact on the design parameters of the vegetable transplanters. As the age of the seedlings increases the above parameters also increases. So, as per the planting suggestions by the horticulturists the above said age of the seedlings which is useful for the sowing of vegetable plants.

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Overview of the influence of environmental factors on seed performance

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ABSTRACT

During crop establishment, seed development and storage, seeds are extremely susceptible to damage. The aim of this review was to examine the scientific data on some of the major environmental factors that influence seed quality. Since it was difficult to cover all aspects of production at once, some factors were selected. Based on the findings of many researchers, it can be said that temperature, humidity, draught, soil salinity, soil acidity, etc. are some of the major factors that strongly influence seed germination, vigor, viability and ultimately affect seed yield.

Key words: Seed deterioration, Seed germination, Crop growth, Yield

INTRODUCTION

In agriculture, the word "seed quality" refers to the overall value of a lot of seed for its usefulness (Hampton, 2002). Successful crop production depends on the production of high quality seeds. Lower seed quality leads to weak seedlings, abnormal growth and maturation and further exposes rice seedlings to pests, diseases, weeds and adverse environmental conditions (Ellis *et al.*, 1995). Environmental factors have a major influence on seed yield, germination and vigor during crop growth and development. Although it is well known that environmental stresses such as temperature and moisture extremes reduce seed longevity and viability. Major abiotic factors affecting seed quality such as temperature, humidity, standing water, frost, fog, drought and nutrients. It is well known that seed viability and germination can vary significantly from season to season and from one production site to another (Hampton, 2002). Seed germination can be affected by unnecessary factors such as flooding, tillage, as well as abiotic factors such as drought,

light, salt, seed burial depth, soil pH and temperature (Cuneo *et al.*, 2010; Baskin CC and Baskin JM, 1998). One of the most important environmental factors affecting seed quality parameters such as seed mass is the temperature experienced by the mother plants during seed development and seed maturation (Peltonen-Sainio *et al.*, 2011). Environmental factors that occur during seed growth, seed development, and seed maturation have a direct effect on seed quality (Copeland and McDonald, 2001; TeKrony *et al.*, 1984).

According to studies, two of the most important environmental factors for promoting seed germination are light and alternative temperature regimes (Baskin CC and Baskin JM, 1998; Presotto A *et al.*, 2014; Vanderlook F *et al.*). Maximum germination percentage and germination rate are considered to be most affected by temperature, and germination usually occurs only in certain temperature ranges (Garcia-Huidobro *et al.* 1982, Hardegree, 2006., Mattana *et al.*, 2010). Water stress during pollination and early stages of seed

development can affect pollen transport and fertilization in maize and also increases early grain abortivity. Environmental stress early in the vegetative growth phase of maize can reduce yield because the developing reproductive primordial, which determines the number of kernel rows and the number of kernels per row, are so sensitive to stress (Slayter, 1969).

A review study was carried out to make most of the harmful effect of some environmental factors on seed performance which are listed below:

Temperature

Seed viability, seed vitality, seed development, crop physiological maturity, proper crop ripening and ultimately harvest of quality seed etc. are greatly affected by temperature. Long-term effects of temperature on seed development and maturation may ultimately affect seed viability. In the case of lettuce, where seeds ripen at high temperatures, Koller (1962) observed that germination occurred at a lower temperature in the dark (260°C) than similar seeds ripened at low temperature. Dormancy patterns in wheat seeds have also been modified by changes in temperature during ripening (Van Dobben, 1947; Kramer, Pest and Witten, 1952) and rice (Ghosh, 1962). Both developing and mature soybean seeds are significantly affected by increasing temperature. When soybean plants are ready for harvest, the ideal temperature ranges from 15 to 22 °C at emergence to 20 to 25 °C at flowering (Liu *et al.*, 2008). Increasing the temperature at the seed filling stage from 29/20 °C to 34/20 °C resulted in lower soybean seed yield (Dornbos and Mullen, 1991). Soybean seed production is maintained on the main stem and branches that originate from the nodes of the main stem (Board, 1987). Most of the vegetative growth of the branch occurs after the growth of the developmental stage (Fehr *et al.*, 1977). The greatest reduction in seed production occurs when stress slows crop growth between growth stages (Linkemer *et al.*, 1998).

According to studies on oilseed rape (Aksouh *et al.*, 2001), instantaneous heat stress reduced seed mass more than continuous heat stress during the grain filling phase. Every component of the seed was lost, resulting in a lower yield. In Australia, cool-season legumes are particularly susceptible to cold or chill damage to reproductive organs, particularly buds that develop only a flower or flowers, reducing seed yield and resulting in poor seed germination, and when in the reproductive stage, field pea. is the pulse most susceptible to frost damage (Siddique *et al.*, 1999). The plant contains some morphological adaptations and changes to protect the leaves from extreme heat. For example, drought and heat tolerance focus exclusively on the same adaptations, such as reflective leaf hairs and waxes, leaf curl and vertical leaf orientation, and the growth of small, highly dissected leaves to reduce boundary layer thickness and thereby maximize convection. and heat loss by conduction (Taiz & Zeiger 2006). The nutritional quality of the seeds is also important for the tin living plant, such as the embryo, when the nutritional quality is reduced, then the seedlings may be abnormal. In oilseeds, the concentration of linolenic acid, protein, phosphorus and oil content is lower at higher temperature (Thomas *et al.*, 2003).

Humidity :

Soybean seed quality can be affected when seed moisture drops from 50% to 15% during the drying phase between physiological maturity and harvest maturity due to warm and humid weather (Howwell, Collins, & Sedgwick, 1959; Tekrony, Egli, & Balles, 1980; Tekrony, Egli and Philips, 1980). According to seed storage research, high storage temperatures and high relative humidity have been associated with seed damage and senescence. As a result, seeds will age when exposed to high temperatures and high moisture levels. This technique is widely used in laboratories to hasten the ageing process of seeds. Such pre-

germination treatments to seeds could reveal important details about their vigour, longevity, and loss of seed viability (A. A. Powell and S. Matthews, 1977). According to studies, drying has its limits and life cannot be prolonged by lowering moisture content below a certain threshold level (C. W. Vertucci *et al.*, 1994).

Drought Stress :

Drought stress is a significant factor affecting pulse productivity. The potential production of faba beans could be reduced by up to 70% as a result of the drought (Siddique *et al.*, 1999). Soybean (*Glycine max* L.) and wheat germination abilities may both be affected by water shortages during the seed filling stage (Ghassemi-Golezani *et al.* 2012 and Tarawneh *et al.*, 2019). Drought stress will have an effect on the seeds' quality and yield during germination. For instance, rapeseed (*Brassica napus* L.) can efficiently produce less seed when drought is applied during sexual reproduction (Ahmandi and Bahrani, 2009). After a lengthy period of water constraint, a plant experiences drought stress, which causes permanent wilting and death may occur (O'Toole, Reference O'Toole 1982). It seems that quality of seed is poor by drought stress during seed development (Barnabas *et al.*, 2008 ; Stagnari *et al.*, 2016). Because of the drought stress during seedfill, diligent researchers have documented declines in soyabean seed germination capacity and vigour (Drummond, Robb, and Melville, 1983; Smiciklas *et al.*, 1989; Dornbos and Mullen, 1991).

Soil :

1. Soil temperature:

Seed germination, crop growth, seed development, and quality of seed are adversely affected by high soil temperature during summer and low soil temperature during winter season. Solar radiation is the primary cause of soil temperature. Temperature of the soil is measured using a thermometer. Seasonal and daily variations in soil temperature may be caused by variations in radiant energy and energy transfer through

the soil surface (Chiemeka, 2010). It affects the biological processes such as availability of nutrition, germination of seed, seedling establishment, and plant root growth (Probert, 2000). Uncontrolled ion outflow is the result of irreversible membrane damage caused by severe changes in temperature in nonhardened plants (Plazek, A.; Zur, I, 2003 and Uemura, M *et al.*, 2006). The ability of plants to absorb water and nutrients is greatly influenced by the soil's temperature (Tosellier *et al.*, 1999).

2. Soil pH:

Macro and micro elements availability in soil is dependent on Soil pH. Acidity in soil reduces the soil's ability to absorb a number of elements, including calcium, magnesium, and phosphorus, and increases the availability of manganese, aluminum, and iron as well as potentially heavy metals like copper and nickel, which can result in the intake of toxic amounts. There are numerous reports of nutrient disorders on high pH and calcareous soils across cold season pulses, including Fe insufficiency in chickpea, lentil, and field pea, as well as Zn shortage in field pea, chickpea, and lentil (Siddique *et al.*, 1999). Al, Fe, and Mn are usually an excess in acidic soils, while Ca, Mg, K, P, and Mo levels may be insufficient (Bradshaw & Chadwick 1980). It has been shown that the poisonous levels of Al contained in acidic soils (Ragland & Coleman 1959) having been shown to prevent seed germination (Hackett 1964) and inhibit root growth (Hackett 1965; Chadwick & Salt 1969; Davies & Snaydon 1973). Nitrification is greatly slowed down and ammonia oxidation proceeds more quickly than nitrite oxidation due to the sensitivity of nitrate bacteria are more (Smith *et al.*, 1997). As a result, nitrite builds up in the soil, which can be poisonous to plants and microbes (Black 1957; Shen *et al.*, 2003).

3. Soil Salinity

In coastal belts of our country, soil salinity is one of the most important factors for hampering seed germination and proper

growth of several crops, as a result quality seed production programme is not done. However, this has a unique set of negative impacts. In arid regions, a large portion of the water in the saline solution evaporates, leaving its salts, like sodium chloride, in the top soil, where they are then present as dissolved salts in irrigation water. Salinization is the term for the buildup of these salts, which can hamper crop growth, reduce crop yield, and eventually kill the crop, making the soil unsuitable for farming. Salinity is considered to affect around 7% of the world's land, and about 20% of the 230 million ha of irrigated land is considered to be salt-affected (Cuneo P et al., 2010). Salinity stress greatly reduces the percentage of seeds that germinate in a range of plants, such as cultivars of *Hordemvulgare* that affect dry weight (Movafegh S et al., 2012), In cotton (*Gossypumhirsutum*), by affecting its various growth parameters such as fresh weight, root and shoot lengths, as well as in Brassica juncea or other plants (Singh P.K et al, 2015; Saleh B, 2012; Jamil M. and ShikRha E, 2013), and rice genotypes by delaying its leaf area (Ali Y et al., 2004). Currently, 30 crop plants—known as glycophytes—produce 90 percent of the plant-based food consumed by humans. The bulk of these crops are salt-sensitive or even not salt tolerant (Sonar B.A., et al, 2011). These crops have seen yield loss when exposed to moderate salinity (EC 4–8 dS m⁻¹, or 40–80 mMNaCl (Zörb C et al., 2019).

CONCLUSION

Having revised the overall picture on effect of environmental factors on seed performance, it is clearly mentioning the negative impact at different stages of seed growth and development, crop establishment and yield. Therefore, farmers and growers those are engaged in seed multiplication programme for obtaining good quality seed, should be aware primarily about the reaction of

temperature, relative humidity, excess draught, soil salinity, soil temperature and pH of soil for applying better management practices.

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Assessing Awareness of Primary and Secondary School Teachers about National Education Policy 2020

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ABSTRACT

The present study was conducted with the objective to assess the awareness of primary and secondary school teachers about basic characteristics of National Education Policy 2020. Total 100 teachers were selected for the study, out of which 50 were from primary level and 50 from secondary level classes. The data was collected through a structured interview schedule shared both personally and via google forms. The results showed higher level of awareness about characteristics like curricular restructuring, skill-based education, foundational literacy, creativity and experiential learning in both the groups. Low awareness was noted in course selection flexibility, development of ethical behaviour, implementation of internships, introduction of ashram shalas, learning through song, play, poetry etc., role of nutrients in development and National Professional Standards for Teachers. Comparatively higher level of awareness was found in secondary level schoolteachers. The study concluded that primary school teachers had lower level of awareness, especially about novel aspects of NEP that did not pertain to their daily teaching earlier.

Key Words: National Education Policy, Awareness, Teachers, Primary education, Secondary education, Vocation, skill.

INTRODUCTION

Indian government has announced the National Education Policy (NEP) in 2020. This policy document is conceptually sound, well-crafted, and futuristic in appearance. It includes the changes aimed at shaking up the current ailing educational system, which is out of step with evolving times and emerging technology.

However, the NEP 2020 document has mixed reviews. Academicians and policy makers have begun studying and researching upon the document and its characteristics. According to Devi and Raju (2020), the NEP

has three major characteristics, viz., high quality, equity and integrity spanning from school to higher education. With the current education emphasizing upon theoretical aspects, the new education policy aspires to develop skill, creative potential and analytical thinking NEP 2020 towards on School Higher education in addresses some challenges facing the existing education system: Quality, Affordability, Equity, Access and Accountability (Gahvane, 2020).

India has one of the world's biggest and most diverse education systems. Although, the country has nearly universalized primary education, there are still significant gaps. The

significant contributors to this gap are non-availability of schools for many of the children, insufficient funds for education cost, education system being filled with prejudices related to marks-based structure and less motivated teachers. NEP seems to be a solution for many of the problems with a mission is to ensure that all Indians have access to a high-quality education at a reasonable cost. NEP 2020's greatest achievement could be that it recognizes the need for less laws, more autonomy, improved teaching and learning methods, better teacher preparation, and more meaningful exams; in other words, it has provided India with a future vision.

NEP 2020 does have ambitious plans to revamp the present education system but its implementers i.e. the teachers have a most significant role to play. It is on their shoulders lies the potential impact of this ambitious document. Action originates from awareness. The teaching fraternity will have to be well aware about the various aspects of NEP 2020 and need to have a clear understanding of what this policy intends. Hence, the present study was conducted with the objective of assessing the awareness level of primary and secondary school teachers about NEP 2020.

MATERIALS AND METHODS

The present research is focused on identifying the awareness levels of primary and secondary school teachers about the National Education Policy 2020. The study was conducted purposively at Varanasi and Gorakhpur district of Uttar Pradesh, with the objective to assess the awareness of Primary and Secondary School Teachers about basic characteristics of National Education Policy 2020, related to school education. Total 100 teachers were selected for the study, out of which 50 were from primary level and 50 from

secondary level classes. The sample was selected through snowball technique questionnaire shared both personally and via google forms. The awareness scores were divided into three categories of low, medium and high levels of awareness. The statistical methods applied for data analysis were percentages and chi square.

RESULTS AND DISCUSSION

Background Information

Information was collected pertaining to the background of the participants to gain a better understanding of their responses and views. Majority of the primary school teachers had the highest educational level of Graduation B.Ed. (34%) whereas the minimum will secondary school teachers holding a postgraduate plus B.Ed. Degree (40%). It was interesting to note that one fourth primary school teachers did not hold a B.Ed. degree, but either had a diploma in elementary education or had done the course of elementary teacher education. The average age of primary and secondary school teachers was 27.32 years and 36.89 years respectively. Majority of the teachers from both the groups were female, married and belonged to urban localities. About 54 percent of the respondents were from government primary schools and 68 percent from government secondary schools. Rest all belonged to the private schools.

Out of the 8 major characteristics (selected for this study) of national education policy 2020 (table 1) it was found that three were most popular in terms of awareness among the schoolteachers. However, the level of awareness varied among the two categories of participants. Awareness about the characteristics of curricular restructuring (78%, 82%), foundational literacy (76%, 64%) and education in regional languages (68%,

Awareness about Major Characteristics of NEP 2020

Table 1: Distribution of the respondents as per their awareness about major characteristics of NEP 2020 n=100

CHARACTERISTICS	PRIMARY SCHOOL TEACHERS (n=50)	SECONDARY SCHOOL TEACHERS (n=50)
Curricular Restructuring of 5+3+3+4	78	82
Integration of essential subjects and skills	54	84
Education in Regional Languages	68	80
Learning by Play	68	42
Emphasis on Foundational Literacy	76	64
Capacity Building of Teachers	42	68
Flexibility in Course Selection	32	40
Support for Gifted students	28	38

Data in percentages.

80%) was found to be the highest in both the groups of participants. Out of these three, only foundational literacy awareness was found to be higher in primary school teachers than secondary school teachers. The teachers were least aware about the flexibility offered in NEP for course selection (32%, 40%) and Support for Gifted students/special provisions for especially abled children (28%, 38%). Less than half of the primary school teachers knew about the capacity building aspect of NEP 2020. The chi square test statistic in case of foundational literacy ($\chi^2=12.8$, $p=0.0001$), regional languages ($\chi^2=14.59$, $p=0.0034$), integration of special education and skills ($\chi^2=5.6$, $p=0.028$) and learning by play ($\chi^2=11.3$, $p=0.0037$) was found to be statistically significant based on a level of significance (0.05).

This data presents an interesting picture, as the aspects most pertaining to their day-to-day job like curricular restructuring, skill-based education etc being well known in the teaching fraternity but at the same time some equally significant yet novel additions like provisions for especially abled children and increased choices in course selection

remaining quite unknown. It was heartening to know that the teachers were aware about the introduction of regional languages in teaching pedagogy. As per the study by Prabu and Mookiah (2021) on the awareness levels of primary school teachers about NEP, it was found that less than quarter of the male primary school teachers had low level, 63.1 % of them had moderate and 15 % of them had high level of awareness. Regarding female primary school teachers, less number of respondents fell into the high levels of awareness. There was a significant difference between the awareness of New Education Policy (2020) primary school teachers' with respect to gender, type of management.

With vocational education (adding fun courses for hands on experience of vocational crafts) gaining highest importance and emphasis in NEP 2020 (Table 2), the awareness levels, sadly, wasn't enough. Secondary school teachers were more aware than primary teachers, especially about the introduction of vocational courses as early as in class VI (and teaching self-reliance at young age). Development of ethical Behaviour through education (like doing what

Awareness about Integration of Essential Subjects and Skills of NEP 2020

Table 2: Percentage Awareness about Integration of Essential Subjects and Skills of NEP 2020

Suggestions	n=100	
	PRIMARY SCHOOL TEACHERS (n=50)	SECONDARY SCHOOL TEACHERS (n=50)
Beginning of Vocational courses (fun course) from class VI-VIII	66	82
Implementation of Internship	52	58
Teaching Self Reliance at young age	44	78
Development of ethical behaviour through Education	24	32

Data in percentages.

is right and giving logical framework for ethical decision which in later stage will expanded to cheating, violence, plagiarism etc) was the least known aspect in this category with less than a quarter of the primary school teachers (24%) recording awareness about it. Overall, primary school teachers showed significantly lower awareness ($\chi^2 = 9.87$, $p = 0.0028$) [based on a level of significance (0.05)] about the vocation related suggestions of NEP 2020. This depicts an indifference on the part of our primary school teachers regarding vocational education, probably stemming from their notion that vocational education is a matter of higher education. With NEP 2020 emphasizing over vocational educational at an early stage, a need to change the outlook of our teachers is imperative.

A study by Maruthavanan (2020) found below average awareness levels of the National Education Policy. There was a significant difference among secondary school teachers on awareness on New Education Policy (2019) based on Gender. Male Secondary School teachers had more awareness than female teachers. Urban secondary school teachers had more awareness than Rural teachers. Government School teachers had more awareness than Self-finance teachers.

Early childhood care and education is

something that has been highly emphasised in national education policy 2020. Some very significant aspects like holistic development, mutual cooperation, learning by play has been inculcated into this new education policy. When it comes to awareness of primary school and secondary school teachers about these aspects of ECCE (table 3), it was found that primary school teachers had a significantly higher awareness (78%) ($\chi^2 = 10.30$, $p = 0.0029$) [based on a level of significance (0.05)] about the personal and public hygiene, teamwork and courtesy related aspects of ECCE whereas secondary school teachers were significantly more aware ($\chi^2 = 9.87$, $p = 0.0003$) [based on a level of significance (0.05)] about the holistic development-based education (80%). Awareness about emphasis on learning through art, story, song, play, poetry and introduction of Ashramshalas was found to be alarmingly low in primary school teachers (24% and 12%). Sports based education system was also fairly unknown in nearly half of the primary school teachers. Findings of this study begs more awareness in our primary and secondary school teachers regarding the early childhood care and education related suggestions of NEP 2020 because the role of our primary and secondary school teachers in implementation

Awareness about ECCE related Suggestions of NEP 2020

Table 3: Percentage Awareness about ECCE related Suggestions of NEP 2020 n=100

Suggestions	PRIMARY SCHOOL TEACHERS (n=50)	SECONDARY SCHOOL TEACHERS (n=50)
Flexible, multi-faceted, multi-level, sports-based education system	54	64
Attention should be given to develop good behavior, courtesy, personal and public hygiene and team work	78	68
Arrangement to achieve maximum results on the basis of holistic development	56	80
Emphasis on learning through art, story, song, play, poetry	24	42
Introduction of 'Ashramshalas' in tribal-dominated areas	12	18

Data in percentages.

of early childhood care and education is going to be most significant. According to Kurien & Chandraman (2020), the New Education Policy announced by Government of India (NEP 2020) was a welcoming change and fresh news amidst all the negativities surrounding the world due to the challenges posed by Covid-19 pandemic. The announcement of NEP 2020 was purely unexpected by many. The changes that

NEP2020 has recommended were something that many educationists never saw coming.

NEP 2020 lays emphasis over strengthening the foundational literacy and numeracy for all children under national mission (rest of the policy will be ineffective if the Indian students are lacking in this skill) via developing reading, writing and arithmetic at foundation

Awareness about Foundation Literacy and Numeracy in NEP 2020

Table 4: Percentage Awareness about Foundation Literacy and Numeracy in NEP 2020 n=100

CHARACTERISTICS	PRIMARY SCHOOL TEACHERS (n=50)	SECONDARY SCHOOL TEACHERS (n=50)
To achieve universal foundational literacy and numeracy in primary school by 2025	78	74
Nutritious Breakfast	24	32
Play Way Method	42	56
Development of physical, intellectual abilities through nutrients	12	20
Enhancing children's love for education	56	88
Regular Health Check-ups	34	68

Data in percentages.

level, nutritious breakfast, play way method, loving to learn, regular health check-ups to ensure good health etc. However, the data revealed (table 4) that apart from the aspect of enhancing children's love for education, foundational literacy and the play way method, awareness regarding the nutrition related aspect of physical and intellectual abilities was extremely low in both the groups as less than a quarter of the participants accepted knowing about the provisions of nutritious breakfast and role of nutrients especially in the foundational years. Inter group comparison showed a significantly higher levels of awareness in secondary

school teachers (88%, 68%) about suggestion of NEP to enhance the love for education in students ($\chi^2 = 8.97$, $p = 0.0042$) and about regular health check-ups ($\chi^2 = 11.43$, $p = 0.0026$) [based on a level of significance (0.05)] than the primary school teachers (56%, 34%). A study by Kaurav *et.al.* (2020) clarified that the objective of NEP 2020 is to strengthen the foundation of education in India by reinforcing holistic development by offering vocational training to students at the elementary and primary education level. The results of the study indicated that the central concern of the government is to evolve the current education system.

Awareness about Skill related Suggestions of NEP 2020

Table 5: Percentage Awareness about Skill related Suggestions of NEP 2020

n=100

CHARACTERISTICS	PRIMARY SCHOOL TEACHERS (n=50)	SECONDARY SCHOOL TEACHERS (n=50)
Enhancing Creativity	90	94
Skill based education to increase employment opportunities	94	82
Experiential learning helps in increasing practical knowledge	84	96

Data in percentages.

The Indian educational scenario has undergone a major shift in the last decade. This shift rose from the lack of specific skills in our degree holders and their sub-optimal performance in the job sector. Efforts have been made to shift our education and pedagogy from mere theories to inculcating practical skills in our student fraternity to make them more job ready. The data (table 5) showed the impact of these efforts as majority of the participants in both groups showed high levels of awareness in all skill related aspects of NEP 2020, be it practical knowledge (84%, 96%), creativity (90%, 94%), or employment opportunities (94%, 82%). It was found that skill related suggestions were known by most

of the teachers, and this indicates a welcome change in the primary and secondary level education of our country. There are many new things proposed in the NEP 2020 to get the right skill set at the right time like vocational courses along with the regular studies if the students opt the right course or subject combination according to the inborn talent the gap between industry and academia will be bridged in near future. Anything new requires some time to yield the results. NEP 2020 proposal has many new things, yet to be implemented and tested there are many areas where people need more clarification (Kalyani, 2020).

Awareness about Teacher related Suggestions of NEP 2020

Table 6: Percentage Awareness about Teacher related Suggestions of NEP 2020 n=100

CHARACTERISTICS	PRIMARY SCHOOL TEACHERS (n=50)	SECONDARY SCHOOL TEACHERS(n=50)
Emphasis on regular teacher recruitment instead of contract teacher	54	78
National Professional Standards for Teachers (NPST) to be prepared by 2022	12	20
Honest teaching work will be encouraged	16	54
Innovation will be emphasized to improve the quality of teaching	34	58

Data in percentages.

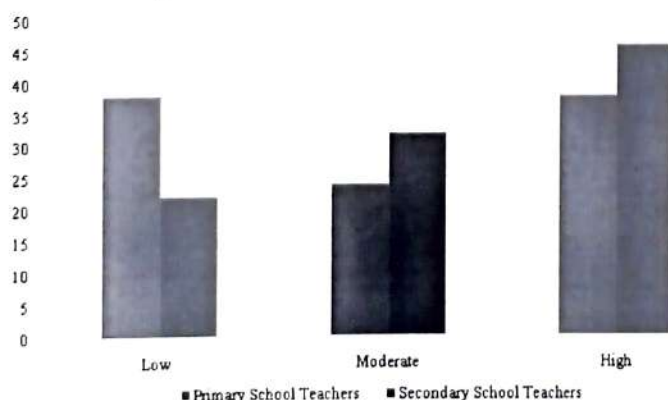
The data (table 6) under this head was found to be very surprising and interesting. Though the suggestions under this head pertained to the teachers themselves, surprisingly, the awareness levels were quite low, especially among the primary school teachers. NEP 2020 has suggested the formation of National Professional Standards for Teachers by the National Council for Teachers Education (in its restructured new form as a Professional Standard Setting Body) meant for quality teaching in the country, however, not even a quarter of the participants knew about this aspect. Nearly 78 percent of the secondary school teachers and over half of the primary school teachers did know of the emphasis over recruitment of regular teachers rather than contractual teachers in NEP 2020. Significant difference was found in the

awareness levels of primary (34%) and secondary school teachers (58%) about the aspect of emphasis on innovation for quality teaching ($\chi^2 = 13.98$, $p = 0.0002$) based on a level of significance (0.05).

In a study (Kalyani, 2020) to assess the awareness of teachers, students and parents about NEP 2020, it was found that the proposal of National Professional Standards for teachers and National Assessment Centre [Parakh] will increase the quality of teaching. It is required as an essential requirement according to the proposal of inviting foreign university to India this will lead to more competitive atmosphere and educators will have to improve. To meet the competition teachers will have to upgrade their knowledge.

Level of Awareness of Teachers about NEP 2020

Fig. 1: Level of Awareness of Teachers about NEP 2020



On the basis of scores obtained by the respondents (fig. 1), it was found that in primary school teacher category, 38 percent had low, 24 percent had moderate, and 38 percent had high level of awareness about NEP 2020. In the secondary school teacher category, 22 percent had low, 32 percent had moderate, and 46 percent had high level of awareness about the various aspects of NEP 2020. Overall, secondary school teachers had comparatively higher levels of awareness about NEP than primary level teachers.

CONCLUSION

NEP 2020 is going to be the driving force and guiding light for the Indian educational system for the decades to come. However, its impact will greatly depend over its understanding among the teaching fraternity, as teachers will be at the forefront in implementation of this NEP 2020. This study endeavoured to identify the awareness about some major characteristics of NEP 2020 among primary and secondary school teachers and found variation among the awareness levels of both the groups and among the characteristics as well. With skill, foundational literacy and regional language related aspects being well known among our teachers, there was an alarmingly low level of awareness about some significant aspects like National Professional Standards, learning through art, behavioural education and provisions for specially abled children. Efforts will have to be made for a better understanding about these aspects in our teaching fraternity. Another prominent finding was the comparatively low level of awareness in our primary school teachers. Their awareness was found to be limited to the older concepts related to their day-to-day teaching like play way method, foundational literacy etc. An indifference was noted in

primary school teachers regarding the newer additions of NEP 2020 that earlier pertained to only higher education and now have been inculcated in early education as well.

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Analyzing the skills widenthrough National Service Scheme among the College Students

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ABSTRACT

The National Service Scheme (NSS) is a Central Sector Scheme of the Government of India, under the Ministry of Youth Affairs and Sports. NSS provides an opportunity to the students of intermediate, technical education, social and moral values to the graduate's students at colleges and universities of India to involve in community development activities. The study is focused on analyzing the difference gained through NSS in personality development and cooperation skills. The study was conducted in the Golaghat and Jorhat districts of Assam. A total of 300 NSS volunteers were chosen as a sample for the study. The data was gathered by using questionnaire through the proportional random sampling method. The findings revealed that the majority of the volunteers had basic knowledge about the NSS, and half of the volunteers (50%) agreed that through NSS their personality has been developed. The volunteers' have favourable attitudes towards NSS. In the both skills, personality development and cooperation skills showed the significant difference before and after joining in the NSS. In the present study, it has found that the NSS programme and its associated activities have a tremendously good effect on volunteers' personalities and cooperation abilities and aid in the accomplishment of the program's primary goals.

Key word: Cooperation, Development, National Service Scheme, Personality, Volunteers,

INTRODUCTION

Different people have different descriptions of their personalities. Personality is defined as a set of behaviors, cognition, and emotional patterns that develop over time as a result of biological and environmental factors. Personality is such a thoroughly researched topic among psychologists that personality psychology has been designated as a separate branch of psychology. Psychology deals with the study of human nature and personality.

The purpose of the NSS regular and special

camping programmes is to bring the volunteers into contact with the community and encourage them to make positive changes in their lives. At weekends or after college hours, students participate in various NSS Regular Activity programmes in the adopted villages, college or school campuses, and urban slums to complete 120 hours during an academic year. Out of the 120 hours, 20 hours are dedicated to NSS volunteer orientation, which includes lectures, debates, field trips, and audiovisuals, and the remaining 30 hours are dedicated to campus labour projects that help

the institution and college.

NSS volunteers have the potential to be great leaders in their lives. To keep up with the modern need of building the overall personality of the youth and preparing them to take on serious responsibilities towards the community and the nation, the rules and regulations mould them into human beings with the best qualities of characteristics, discipline, behavior, and so on. Future research should look into the relationship between an individual's personality traits and their employees to determine if their career is successful or unsuccessful.

Intrapersonal Intelligence is a new marker that was created to give this vital part of our personality development and grooming its proper weight. A person who runs away from his self and tries to fill the void with other interests or shallow connections is on the verge of a crisis. The extrovert's feelings of self-worth and esteem are heavily influenced by how others perceive him. An introvert is someone who strives to reach a point where they might feel good or be content without needing external validation. (Pramod Kumar 2016).

Jaya Bharti et al (2021) found that the characteristics of NSS students and non-NSS students differ significantly. In comparison to other students, NSS students have more mental intentions to serve. Their characteristics and personalities were shaped by this intention and have seen considerable changes in students who scored poorly before joining the NSS. The rules and regulations mould them through NSS beings into the highest levels of character, discipline, and behavior. While taking non-NSS students, the range of activities has been greatly increased to meet the present necessity of developing the overall personality.

NSS units can participate in any activity that benefits the community. The programmes will continue to evolve in response to community requirements. Education and literacy, health, family welfare and nutrition, sanitation and cleanliness, environmental conservation, social service programmes, programmes to improve women's status, production-oriented programmes, disaster relief and rehabilitation, creating awareness about government key initiatives such as Digital India, Skill India, and Yoga Promotion, among others, could be among the core activities.

The present study assess the knowledge and attitude of NSS volunteers and examine the development in personality and co-operation skills of NSS volunteers.

MATERIALS AND METHODS

The current research was conducted in two different districts of Assam, namely the Golaghat and Jorhat districts. From the Golaghat district HPB girls' college and Jorhat district, Assam Agricultural University was chosen as the area for the research. The total sample for the study was 300 NSS volunteers, who were selected through the proportional random sampling method. Seventy volunteers from HPB Girls' College and 230 volunteers from Assam Agricultural University were undertaken as a sample for the current research. The study was conducted in February 2020 with the age group of 17–20-year-old NSS volunteers.

The method of the present research is a descriptive research method; where the researcher wanted to find out about different aspects, including personality, frequency, trends, and classifications, they utilized a descriptive study approach. To keep pace with the goals of this research, the data was coded, categorized, and tabulated.

Percentage analysis and a paired sample t-test were used to analyze the data. A statistical method is used to assess whether the mean difference between two sets of observations is zero. It is known as the paired sample t-test or dependent sample t-test. The paired sample t-test produces pairs of observations by measuring each subject or thing twice. In the present study paired sample t-test has been used to find out the difference among the volunteers after joining the NSS in acquiring personality development and cooperation skills.

RESULTS AND DISCUSSION

The Table 1 illustrates the knowledge about NSS among the volunteers. It is amazing to note that all the volunteers knew the father of NSS, the NSS motto, the year NSS was found in India, the date and month of the NSS day celebration, and the duration of the NSS special camp. Eighty percent volunteers were aware of the aim, duration of NSS volunteership, and the logo of the NSS. The majority of the volunteers (70%) knew the duration of NSS as a regular activity and the age limit for joining NSS. From the above data, it has been perceived that the majority of the volunteers were aware of basic facts about NSS, and it was a good sign for the programme that the volunteers had joined with their knowledge.

Table 1. knowledge of the respondent about NSS among the volunteers

		n=300	
Knowledge on NSS		f	%
Establishment year of NSS in India	1969	300	100
Father of NSS	Dr. V.K.R.V Rao	300	100
Aims of NSS	Personality Development through community service	300	100
Motto of NSS	Not Me, But You	300	100
Duration of NSSas a regular activity	110 hours	60	20
	120 hours	210	70
	130 hours	30	10
	2 years	240	80
Duration of NSS Volunteership	3 years	9	3
	More than 3 years	51	17
	15-25 years	75	25
	18- 25 years	210	70
Age limit in joining NSS as a volunteer	18-27 years	15	5
	24th September	300	100
	7 days	300	100
Date and month of NSS Day Celebration			
Duration of NSS Special Camp			
The logo of NSS	Motive the volunteers to nation-building and social activity	240	80
	Principle of life	60	20

*F = frequency, *P= percentage

Table 2. Attitude towards NSS among the volunteers

Statements	n = 300				
	A (%)	SA (%)	N (%)	D (%)	SD (%)
It is helpful for personality development	50	23	11	6	10
It develops self-confidence	28	43	5	9	15
It helps in socialization	61	12	8	14	5
It provides spacious experiences in life	31	26	10	20	13
NSS does not help to improve literacy in a nation	27	15	30	14	14
It helps to increase positive thinking	39	20	13	17	11
Feel proud to be a part of NSS	54	14	16	6	10
It should be a compulsory part of the curriculum	27	36	14	11	12
It helps the NSS volunteers to lead an independent life	41	28	11	6	14
NSS helps the volunteers gain mental strength	25	14	33	8	20
It provides a change from routine classroom learning	22	40	16	9	13
Special camps provide an opportunity to adjust to a challenging situation	33	25	19	8	15

*Multiple responses, A*Agree, SA*strongly agree, N*Neutral*Disagree,SD* strongly disagree

The data stated that half of the volunteers agree that NSS is helpful for personality development while 23 per cent strongly agree with the same statement. This could be because volunteers in NSS participate in a variety of developmental activities, all of which contribute to the overall development of the volunteer in this statement, strongly disagreed with 10 per cent by the volunteers. Sixty one percent of the volunteers agreed that it helps in socialization and 54 per cent were felt proud to be a part of the NSS, it might be the reason that the volunteers enhance their skills and developed their personality through NSS. Similarly, Bhola Nath et al., (2014) found that NSS is mostly an eccentric student activity that takes place "outside of the classroom," in which teachers solely serve as advisors to the principal performers, the students. Instilling in students a feeling of leadership and teamwork empowers them to recognised community challenges. As a result, leadership, unity, social responsibility, and community involvement are constantly at play.

Additionally, they are remarkably similar to social and environmental reality attributable to these qualities.

Forty-three of the volunteers stated that NSS has developed confidence among the volunteers, whereas 5 per cent of the volunteers were neutral and 15 per cent of the volunteers strongly disagreed with the statements. The thirty nine per cent of volunteers agreed that NSS aided in the development of positive thinking, while 13 per cent were undecided. Sixty-one percent of the volunteers agreed that NSS helps in socialization because all activities are carried through groups; therefore, volunteers get an opportunity to mingle with different kinds of people in the community as well as among peers. The statement received a neutral response from 8 per cent of the volunteers, while 14 per cent of the volunteers disagreed with the statement. Thirty-one percent of the volunteers agreed that NSS provides spacious experiences in life, while 13 per cent strongly disagreed with this. Thirty-nine per cent of volunteers strongly agreed with this

because some colleges prioritize students' needs and interests when recruiting for NSS. Forty-one per cent of volunteers agreed that NSS helps volunteers lead independent lives. In special camps, volunteers stay apart from their families and carry out all activities on their own.

Forty percent of the volunteers strongly agreed that NSS provided a change from routine classroom learning. In NSS, volunteers became more sincere, and disciplined, and enhanced their academic performance. Thirty three percent of the volunteers agreed with the statement that NSS special camp provides an opportunity to adjust to a challenging situation because they are spaced out from their families in a remote area and managing life by themselves is a

tricky phase for a volunteer, whereas 8 percent of the volunteers disagreed with this statement. Likewise, Dhananjay Lokhande (2006) revealed in his study that NSS activities resulted in a significant increase in self-confidence, communication skills, social commitment, problem-solving skills in personal and public life, and a positive attitude among NSS student volunteers. The student Volunteers felt fulfilled as a result of their involvement in nation-building programmes. Members of the community acknowledged the influence of NSS activities through increased awareness of health and environmental concerns, improved social behavior, and understanding of the causes of pollution.

Table 3. Personality Development through NSS

							n=300
S.No	Statements		Mean	SD	SE	t-value	Sig
1.	I can manage everything	Before	2.43	1.00	0.04	14.808	.000*
		After	3.08	1.20	0.05		
2.	Having faith in other's decision	Before	2.33	0.99	0.04	8.809	.000*
		After	2.33	0.99	0.04		
3.	I can understand the emotion of the other	Before	2.36	1.14	0.05	-6.936	.000*
		After	2.65	1.12	0.05		
4.	I can communicate well with all	Before	2.30	1.19	0.05	-16.806	.000*
		After	3.18	0.89	0.04		
5.	Having the determination to do the right things	Before	2.32	1.15	0.05	-5.706	.000*
		After	2.55	1.22	0.05		
6.	Get upset easily	Before	2.50	1.03	0.04	2.664	.008**
		After	2.61	1.11	0.05		
7.	Think before doing an activity	Before	1.01	0.10	0.00	103.181	.000*
		After	2.79	0.41	0.02		
8.	Being quiet when others are discussing something	Before	1.97	0.55	0.02	-45.175	.000*
		After	2.87	0.44	0.02		
9.	Never ignore problems	Before	1.89	0.49	0.02	.214	.831NS
		After	1.90	0.51	0.02		
10.	Never gossip about others	Before	1.35	0.66	0.03	-16.584	.000*
		After	1.89	0.49	0.02		
11.	Love to spend time with nature	Before	2.35	0.98	0.04	11.581	.000*
		After	2.92	1.24	0.05		
12.	Unable to adjust to the small issues in life	Before	2.18	0.96	0.04	4.506	.000*
		After	2.38	1.15	0.05		

13.	Kind of reserve person	Before	2.09	1.06	0.04	-1.525	.128NS
		After	2.15	1.05	0.04		
14.	Treating others as I would like to be treated	Before	2.12	1.11	0.05	-7.155	.000*
		After	2.51	1.13	0.05		
15.	Not rude to others	Before	1.99	1.02	0.04	-7.972	.000*
		After	2.40	1.30	0.05		
16.	I became a debater	Before	2.80	1.36	0.06	-3.391	.001*
		After	2.98	1.35	0.06		
17.	Always having a smiling face	Before	2.43	1.64	0.07	12.427	.000*
		After	3.16	1.15	0.05		
18.	I am aware of myself	Before	3.06	1.33	0.05	-5.410	.000*
		After	3.33	0.94	0.04		
19.	More ambitious regarding my goals	Before	2.33	1.06	0.04	4.639	.000*
		After	2.50	1.14	0.05		

*= Significant at 1% level, **= Significant at 5% level, NS = Not Significant

The data show on the Table 3 the difference in personality development among the volunteers before and after joining NSS. Among the nineteen variables fifteen variables were found to be significant at a 1 percent level they were, the volunteers can manage everything; having faith in other's emotions, they can communicate well with all the people; have the determination to do the right things; think before doing an activity, the highest t value found in this variable 103.181; being quiet while others discussing something; never ignored problems; never gossip about others; love to spend time with nature; treating others as they like to be treated; not rude to others; they become a debtor; always having smiling face; and always aware of themselves; they were more ambitious regarding their goal. Similarly, Anita

Maruti(2022) suggested in her study that the N.S.S. camp activities will undoubtedly enhance community communication abilities, teamwork, volunteer leadership and other qualities. Students have a way to manage common social activities thanks to daily practice. Students are given the opportunity through the National Service Scheme to reflect on the needs and difficulties facing society. Volunteers for the NSS gained knowledge from the experience and used it to influence effectively current events. The National Service Scheme has shown a critical role for society, community involvement in social activities, and volunteer engagement in social activities, the desires and priorities of aliveness in society are discovered among volunteers through their participation in national disasters.

Table 4. Cooperation skills among NSS volunteers:

		n=300					
S.No	Statements		Mean	SD	SE	t-value	Sig
1.	Helping parents in household activities	Before	1.79	0.71	0.03	4.301	.000*
		After	1.97	0.94	0.04		
2.	Sharing my things with friends	Before	1.74	0.65	0.03	13.891	.000*
		After	2.29	0.71	0.03		
3.	I can monitor my programme effectively	Before	1.81	0.65	0.04	3.729	.000*
		After	1.99	0.86	0.05		

4.	Extending my support to my friend	Before	4.05	0.82	0.05	6.291	.000*
		After	4.37	0.77	0.05		
5.	I take help from others	Before	4.27	0.75	0.05	.102	.919NS
		After	4.27	0.97	0.06		
6.	Admire others' ideas in group activities	Before	3.51	1.27	0.08	4.107	.000*
		After	3.86	0.82	0.05		
7.	Ability to work in harmony	Before	4.01	0.86	0.05	9.066	.000*
		After	4.45	0.96	0.06		
8.	Counseling friends who are in trouble	Before	1.62	0.62	0.03	21.596	.000*
		After	4.12	0.89	0.04		
9.	Polite and kind towards teammate	Before	1.61	0.49	0.02	11.296	.000*
		After	2.55	0.53	0.02		
10.	Solving the issues among peers without involving teachers	Before	1.42	0.49	0.02	8.404	.000*
		After	1.70	0.58	0.02	0.02	
11.	Answering others clearly and consciously	Before	1.62	0.49	0.02	24.881	.000*
		After	2.47	0.59	0.02		
12.	Accepting differences of opinion and moving forward	Before	1.58	0.49	0.02	3.690	.026**
		After	1.67	0.58	0.02		
13.	Accepted others' ideas in group activities	Before	2.12	0.65	0.02	09.652	.001*
		After	2.03	0.78	0.03		
14.	Doing teamwork makes me happy	Before	1.61	0.52	0.02	19.567	.000*
		After	2.29	0.55	0.02		
15.	I can monitor my team	Before	1.23	0.78	0.01	14.259	.000*
		After	2.45	0.98	0.03		

*= Significant at 1% level, **= Significant at 5% level, NS = Not Significant

The above table affirmed that out of the 15 statements, 13 statements showed significance at a 1% level, whereas the highest t value was shown with the statements that answered others clearly and consciously. In this statement, the volunteers stated that after joining the NSS they learned good manners in dealing with different kinds of people. Another statement "counseling friends who are in trouble" showed a t value of 21.596. The NSS volunteers had seen the real-life situation on the ground and they had implemented various activities to overcome their problems. In this way, the volunteers were able to solve their peers' troubles by themselves. The 3rd statement, which has the highest difference seen after joining NSS (t value 14.259), was that they could monitor their team. It has been seen that after joining the NSS, the volunteers became independent

people and enhanced their leadership qualities, whereas the lowest t values (13.891) were shown at a 1% significant level with the statement "I can monitor my programme effectively." The statement "accepting difference of opinion and moving forward" showed significance at a 5% level (t value 3.690). In NSS, volunteers were trained to adjust to different kinds of people so that they have adapted to different food habits, cultures, and philosophies and it has increased their acceptance quality in day-to-day life. The statement "I take help from others" showed a non-significant difference with the t value of .102. And it has been confirmed that NSS provides a platform where volunteers can gripe about their challenges by themselves without taking help from others.

Vijay Behere (2012) studied that the NSS volunteers learn to adjust themselves to society. During the special camping program NSS volunteers establish cordial relations with villagers. They undertake developmental activities like work related to hospitals, child labour, aged persons, and citizens. Through such close interaction between the volunteers with the village community, volunteers gain insight into the problems of society. A positive approach is created among the volunteer and get an opportunity to develop their cooperation skills. In NSS, volunteers are more easily motivated to learn when dealing with real-life problems that need solutions. There was increased awareness of the community and world around them. It teaches volunteers to develop compassion and empathy for others. The social benefit of NSS is a deep appreciation of Indian society and its traditions.

CONCLUSION

The NSS program can reach its goals and it has been reflected in the present study. The study found that the volunteers were aware of basic facts about the programme and also have a favourable attitude towards the scheme. NSS imparts significant changes among the volunteers in personality development and cooperation skills after joining the NSS. The majority of the statements were found to be significant at a 1% level after joining the NSS. The highest t value found in the statement on that the volunteers think before doing an activity (103.181) in their personality development skill. In the cooperation skill the statement answering others clearly and consciously found the highest significance difference (t – value 24.881). The NSS significantly contributes to the improvement

of volunteer cooperation and personality development. The volunteers participate in a variety of activities under this programme, such as raising public awareness of current concerns like the environment, health, the welfare of women and children, and the plight of the poor and oppressed. For the purpose of fostering the development of students' personalities, special camps such as the national integration camp, adventure camps, mega summer camps, republic day parade camps, etc. The varied physical, intellectual, social, and cultural activities that are part of camp are included. Students take part in discussions, brainstorming sessions, and other group activities. The volunteers have noticed a change as a result of joining the NSS through its programmes and camps.

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Antimicrobial and Antioxidant activity of Copper Nanoparticles Synthesised from *Centella asiatica*

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ABSTRACT

Copper nanoparticles can be synthesised using various methods, including chemical reduction, thermal decomposition, and green synthesis approaches. The present study focuses on the green synthesis of copper oxide nanoparticles from the leaf extract of *Centella asiatica*. The synthesised copper nanoparticles were characterised by a UV-visible spectrophotometer, which gave an optical absorbance spectrum at 204.8 nm, and by X-ray diffraction, Bragg's reflection 2θ was 30.334° . The synthesised copper nanoparticles exhibited good antimicrobial activity against pathogenic strains of *Bacillus velezensis*, *Klebsiella ozaenae*, *Pseudomonas aeruginosa*, and *Proteus vulgaris*, with the minimum inhibitory concentration of *Bacillus velezensis* and *Proteus vulgaris* being 0.6 $\mu\text{g/ml}$. The copper nanoparticles showed antioxidant activity with the DPPH method and the FRAP reducing assay.

Key words : Copper Nanoparticles, Antimicrobial, Antioxidant, X-Ray Diffraction, UV Visible Spectrophotometer

INTRODUCTION

Nanotechnology is a multidisciplinary field of research that integrates material science with bioscience and engineering [Tan *et al.*, 2020; Abu Rakheyet *et al.*, 2022; Zhang *et al.*, 2019; Wei *et al.*, 2020]. Nanoparticles are materials, namely metals, metal oxides, or semiconductors (quantum dots), with sizes ranging from 1–100 nm. Metals such as gold, silver, platinum, zinc, or copper, due to their unreactive or less reactive nature, are commonly used for the synthesis of nanoparticles [Khatua *et al.*, 2019; Sharma *et al.*, 2018; Ganaieet *et al.*, 2018; Rajini *et al.*, 2022; Hano & Abbasi, 2022]. Nanoparticles can be produced by physical, chemical, and biological methods, with the biological method using microorganisms or plant extracts being an eco-friendly approach. The

use of plant extracts reduces the cost of microorganism isolation and culture media, enhancing the cost-competitive feasibility of nanoparticle synthesis by microorganisms. Green synthesis of metal nanoparticles finds applications in catalysis, electronics, optics, the environment, the medical and pharmaceutical industries, as well as biotechnology [Faisal *et al.*, 2020; Shafey, 2020].

Centella asiatica (family Apiaceae) is a psychoactive medicinal plant that has been used for centuries in the ayurvedic system of medicine as a *Medya Rasayana*. *Centella asiatica* has been used as a medicinal herb in India, China, Nepal, Sri Lanka, and Madagascar for many years. It is reported to possess various pharmacological activities, including wound healing, anti-microbial, anti-cancer, anti-inflammatory, hepatoprotective,

insecticidal, and anti-oxidant activities [Torbaty *et al.*, 2021]. *Centella asiatica* is rich in terpenoids, with asiaticoside being characterised for its pharmacological importance [Park, 2021].

Due to the unique properties of copper nanoparticles (CuNPs), such as high electrical conductivity, low electrochemical migration behaviour, a high melting point, and low cost, they can serve as alternatives to noble metals in applications like inkjet printing, organic transformations, gas phase catalysis, photocatalysis, and electrocatalysis (Tamilvanan, 2014). The solvents, stabilising agents, and reducing agent used for the biosynthesis of CuNPs should be non-toxic. This emphasizes that the synthesis of CuNPs is a bottom-up method. Copper nanoparticles find applications in industries such as medicine and electronics.

A nanocomposite of copper and manganese oxide, synthesised using *Centella asiatica* leaf extract, serves as a recyclable heterogeneous catalyst capable of reducing dyes such as dinitrophenyl hydrazine, rhodamine B, methylene blue, and congo red in the presence of sodium borohydrate in water at room temperature. This demonstrates the efficacy of nano-particles in wastewater treatment, catalysis, and medicine (Nasrollahzadeh *et al.*, 2018). The primary objective of this study is to assess the synthesis, characterization, and investigate the antibacterial and antioxidant properties of copper nanoparticles derived from *Centella asiatica* leaf extract. Additionally, we aim to elucidate the potential applications of these nanoparticles in addressing bacterial infections and oxidative stress-related disorders, highlighting their potential as novel therapeutic agents with natural origins. This research contributes to the broader understanding of bio-based nanoparticles and their multifaceted properties for future

biomedical and environmental applications.

MATERIALS AND METHODS

2.1 Preparation of *Centella asiatica* extract:

Fresh leaves of *Centella asiatica* (Figure 1), collected from Manikkal, Thiruvananthapuram, Kerala, were washed several times with tap water to remove the dust particles and dried in the shade for 7 days. The plant extract was prepared by mixing 20g of dried leaf powder with 100 ml of double-distilled water in a 250 ml glass beaker. The solution was then boiled at 100°C for 60 minutes until the colour of the solution changed. The extract was filtered with Whatman No. 1 filter paper, stored at 4°C, and used for further analysis.



Figure 1: Leaves of *Centella asiatica*

2.2 Synthesis of Copper Nanoparticles

An aqueous solution of 2 mM copper acetate was prepared and used for the synthesis of copper nano-particles. Five milliliters of the prepared leaf extract were mixed with 50 ml of 2mM aqueous copper acetate solution in a 100 ml conical flask and stirred for 10 hours using a magnetic stirrer at room temperature. The colour of the solution changed to a dark green. The solution was centrifuged for 30 minutes at 5000 rpm. The pellets obtained

were washed, transferred to a petri plate, and dried in a hot air oven at 80°C for 2 hours.

2.3 Characterization of Copper Nanoparticles

2.3.1 UV-VIS Spectroscopic Analysis:

The copper nanoparticle was characterised using the Systronics M2202 double beam UV-visible spectrophotometer, operating between 200-800nm with a spectral bandwidth of 2nm.

2.3.2 X-ray Diffraction:

The X-ray diffraction measurements of copper nanoparticles were conducted using a Bruker D2 Phaser X-Ray Diffractometer. The diffraction pattern was recorded with a wavelength of 1.54 Å in the 2θ range from 10.002 Å to 80.010 Å, with a step size of 0.020° and a time constant of 0.30 sec.

2.4 Antibacterial Activity of Copper Nanoparticles

To determine the antibacterial activity of copper nanoparticles, pathogenic strains of *Bacillus velezensis*, *Klebsiella ozaenae*, *Pseudomonas aeruginosa*, and *Proteus vulgaris* were used, following the agar-well diffusion method. The test organisms were prepared by inoculating a loop full of stock culture into a test tube containing approximately 5 ml of nutrient broth, and allowing it to incubate for 3 hours.

Muller-Hinton media were prepared, sterilised, and poured into the Petri plates. After solidification, the culture broth was inoculated onto agar plates using the swab method. Wells were created using cork-borers. Copper acetate and gentamycin were employed as negative and positive controls, respectively. Copper nanoparticles, as well as positive and negative controls, were added to each well. The plates were then incubated for 24 hours at 37°C, and after incubation, the zone of inhibition was measured.

2.4.1 Minimum Inhibitory Concentration (MIC)

The MIC was determined by the agar-well diffusion method. The MIC was defined as the lowest concentration of an antimicrobial that would inhibit visible growth.

Mueller-Hinton medium was prepared, sterilised, poured into Petri dishes, and allowed to solidify. Test bacterial strains were inoculated onto the plates with the help of a sterile cotton swab. Wells were made aseptically using a corkborer. The different concentrations (0.2 µg/ml, 0.4 µg/ml, 0.6 µg/ml, 0.8 µg/ml, and 1 µg/ml) of 100 µl of nanoparticles were added to each well. The culture was incubated at 37°C for 24 hours. MIC was recorded as the lowest concentration of nanoparticle that showed a zone of inhibition.

2.4.2 Minimum Bactericidal Concentration (MBC)

Minimum bactericidal concentration is the lowest concentration of antimicrobial that will prevent the growth of an organism after subculture on an antibiotic-free medium. The determination of MBC is done by the dilution method. The test bacterial strains were inoculated onto Mueller-Hinton agar media plates, and different concentrations (0.2 µg/ml, 0.4 µg/ml, and 0.6 µg/ml) of nanoparticles were spread onto them. The culture was incubated at 37°C overnight. The lowest concentration, which had no single colony of bacterial growth, was taken as MBC.

2.5 Antioxidant Activity of Copper Nanoparticles

Antioxidant activity of copper nanoparticles was determined using DPPH and FRAP assays.

2.5.1 DPPH Radical Scavenging Activity: DPPH (2,2-diphenyl-1-picryl-hydrazyl hydrate) radical scavenging activity was measured according to the method of Brand-

Williams *et al.*, (1995), with certain modifications. A methanolic solution of 0.1 mM DPPH (4 mg/100 ml) was prepared freshly. 0.3 ml of synthesised CuNPs were added to 2.5 ml of DPPH solution. Reaction mixtures were kept in the dark for 30 minutes, and a decrease in absorbance was measured at 515 nm. Ascorbic acid was taken as a standard.

The scavenging activity percentage (AA%) was determined according to the equation.

$$AA\% = \frac{A_{\text{control}} - (A_{\text{sample}} - A_{\text{blank}})}{A_{\text{control}}} \times 100$$

where A is the absorbance of the synthesised CuNPs.

A control is the absorbance of the control (methanol + DPPH).

A blank is the absorbance of blank (methanol).

2.5.2 Ferric Reducing Antioxidant Power (FRAP) Assay:

The FRAP assay was performed following the method outlined by Benzie and Strain (1996), with some modifications. A freshly prepared FRAP solution, consisting of 50 mL of 0.3M acetate buffer (pH 3.6), was combined with 5 ml of a 10 mM of tripyridyltriazine (TPTZ) solution in 40 mM HCl and 20mM FeCl₃ solution. Subsequently, 900 l of FRAP solution was mixed with 300 µl of sample and diluted to a final volume of 1500 µl using distilled water. The ferric chloride-reducing ability was assessed after a 15-minute incubation in darkness, and the absorbance was measured at 595 nm.

Reducing activity(%) =

$$\frac{A_{\text{control}} - (A_{\text{sample}} - A_{\text{blank}})}{A_{\text{control}}} \times 100$$

A control is the absorbance of control.

A blank is the absorbance of blank.

RESULTS AND DISCUSSION

3.1 Characterization of Copper Nanoparticles:

The formation of copper nanoparticles in the leaf extract of *Centella asiatica* was visualised as a colour change from light green to dark due to the reduction of copper ions (Figure 2).

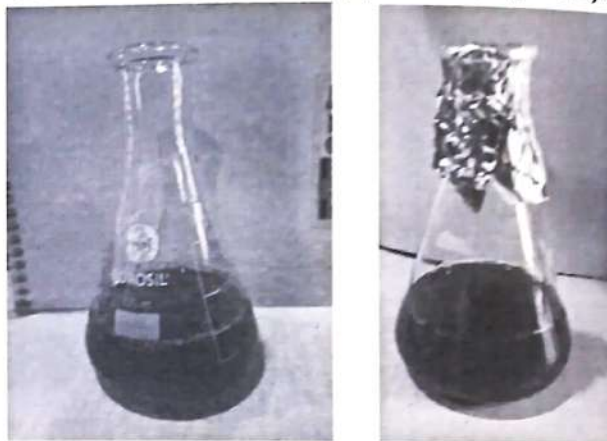


Figure 2: Leaf extract of *Centella asiatica* (left) and copper nanoparticles synthesised (right)

The copper nanoparticles in powder form displayed a dark green hue. To ascertain their configuration, which was attained through the reduction of aqueous metal ions when exposed to *Centella asiatica* leaf extract, we monitored them using UV-VIS spectroscopy. The UV Visible spectrum is depicted in Figure 3. The surface plasmon resonance absorption band of Copper nanoparticle was obtained at 204.8nm. This aligns with previous research findings, where the surface plasmon resonance absorption band of Cu nanoparticles typically falls within the range of 220-235nm, as demonstrated by Rehana *et al.*, in their 2017 study. Furthermore, the UV-visible spectrum analysis of copper oxide nanoparticles conducted by Renuga *et al.* in 2020 also revealed a resonance peak at approximately 220nm. These consistent observations underscore the characteristic spectral behaviour exhibited by copper

nanoparticles in this specific wavelength range.

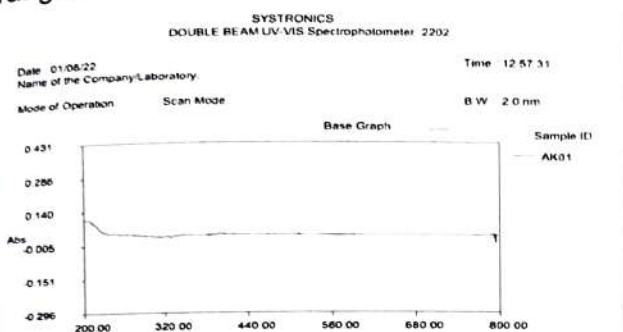


Figure 3. UV – VIS spectrum of CuNPs.

The verification of copper nanoparticles' formation, synthesised using the leaf extract, was further substantiated through X-ray diffraction (XRD) measurements. In this context, the XRD analysis revealed distinctive Bragg's reflections, with a 2θ angle of 30.334° , as illustrated in Figure 4, for the CuNPs synthesised from *Centella asiatica*. Notably, in a study conducted by Kavitha et al., in 2022 involving copper nanoparticles derived from *Catharanthus roseus*, multiple Bragg's reflections were identified at specific 2θ angles, including 33.53° , 35.82° , 38.78° , 48.99° , 55.75° , 58.64° , 62.26° , 55.75° , 58.64° , 62.26° , and 67.34° . The X-ray diffraction pattern of copper nanoparticles derived from *Oscimum sanctum* leaves exhibited a broad halo in the 2θ range of $20 - 40^\circ$, confirming their amorphous nature (Usha et al., 2017). Copper nanoparticles synthesised from *Capparis zeylanica* exhibited distinct diffraction peaks at 39.1°

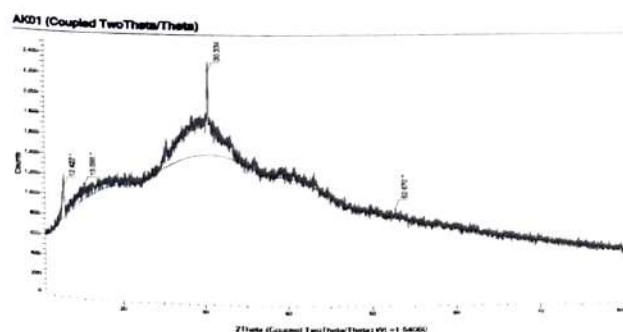


Figure 4: XRD spectrum of CuNPs.

and 68.3° in their XRD spectrum (Saranyaadev et al., 2014). In their XRD analysis, Fatma et al. (2017) observed specific peaks at 2θ values of 42.47° for CuNPs synthesised from *Passiflora foetida* leaf extract.

3.2 Antibacterial Activity of Copper Nanoparticles

The antibacterial activity of the synthesized copper nanoparticles from the leaf extract of *Centella asiatica* was assessed against two Gram-positive and Gram-negative pathogens; *Pseudomonas aeruginosa*, *Bacillus velezensis*, *Klebsiella ozaenae*, and *Proteus vulgaris*. The results demonstrated promising antibacterial activity against all of these pathogens (Figures 5, 6, 7, and 8). The zone of inhibition created by the copper nanoparticle indicated that they were more effective than the positive control used (Table 1). *Klebsiella ozaenae* exhibited the lowest antibacterial activity.

In a study by Netala et al. (2014), silver nanoparticles synthesised from the aqueous callus extract of *Centella asiatica* exhibited potent inhibitory activity against *Escherichia coli*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, and *Bacillus subtilis*, with corresponding inhibition zones measuring 16.2mm, 18.8mm, 21.3 mm, and 19.4 mm, alongside a distinctive surface plasmon resonance peak observed at 453nm.

Table 1. Antibacterial activity of CuNPs against different bacterial strains

Bacterial strain	Zone of inhibition		
	CuNPs (mm)	Positive control (mm)	Negative control (mm)
<i>Bacillus velezensis</i>	21 + 0.29	18 + 0.16	Nil
<i>Proteus vulgaris</i>	20 + 0.23	18 + 0.08	Nil
<i>Pseudomonas aeruginosa</i>	16 + 0.12	12 + 0.04	Nil
<i>Klebsiella ozaenae</i>	11 + 0.12	9 + 0.09	Nil

In contrast, zinc oxide nanoparticles, produced using an aqueous leaf extract of *Centella asiatica*, demonstrated antibacterial activity against *Escherichia coli*, *Pseudomonas aeruginosa*, and

Staphylococcus aureus. The respective zones of inhibition for these bacteria measured 10mm, 12 mm, and 8 mm. (Rajini et al., 2022).

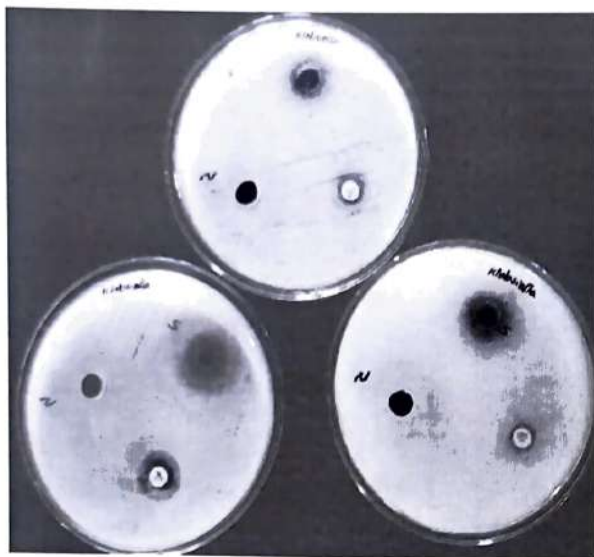


Fig.5 : Antimicrobial activity of synthesized CuNPs against *Klebsiella ozaenae*

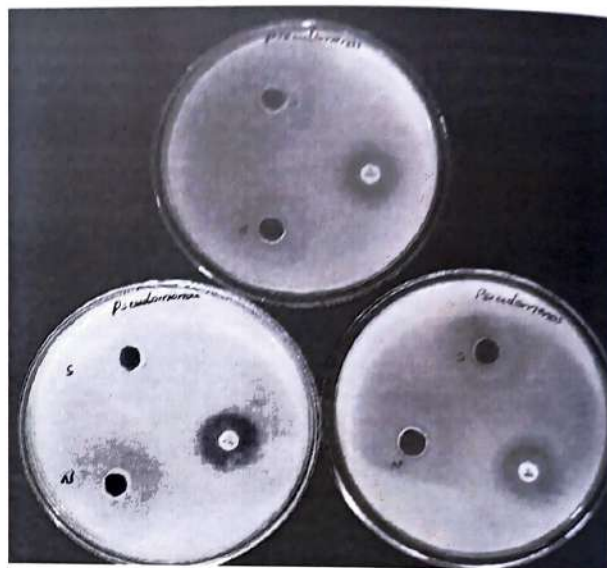


Fig.6: Antimicrobial activity of synthesized CuNPs against *Pseudomonas aeruginosa*

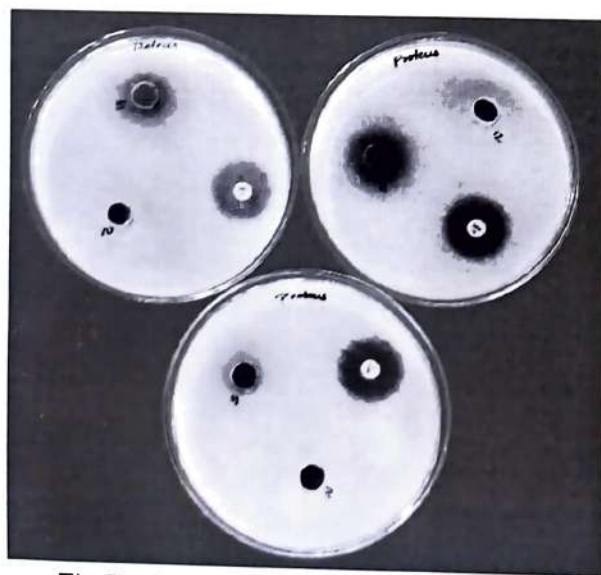


Fig.7 Antimicrobial activity of synthesized CuNPs against *Proteus vulgaris*

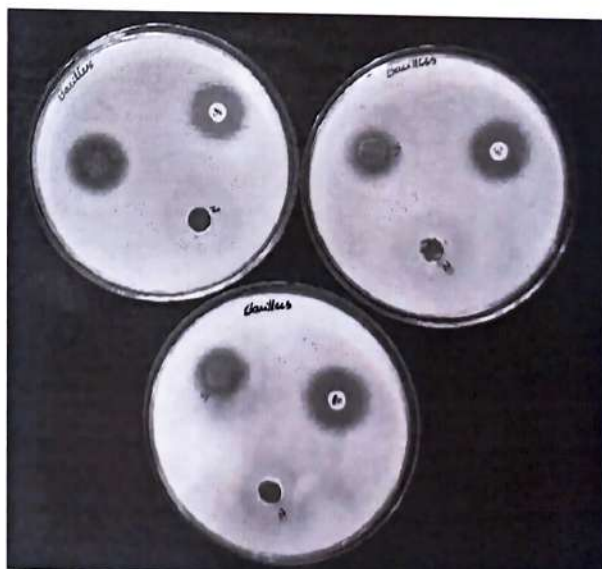


Fig.8: Antimicrobial activity of synthesized CuNPs against *Bacillus velezensis*

Fig.9: MIC of *Bacillus velezensis*

Minimum inhibitory concentration of *Bacillus velezensis* and *Proteus vulgaris*: the lowest concentration of an antimicrobial that will inhibit the growth of a given strain of bacteria was 0.6 µg/ml (Figures 9 and 10; Table 2).

Minimum bactericidal concentration (MBC): The lowest concentration of antimicrobial that resulted in no colony growth was taken as the MBC. The MBC results revealed that the synthesised CuNPs significantly inhibited the growth of bacteria. The lowest MBC concentration was observed at 0.6 µg/ml for *Bacillus velezensis* (Figure 11).

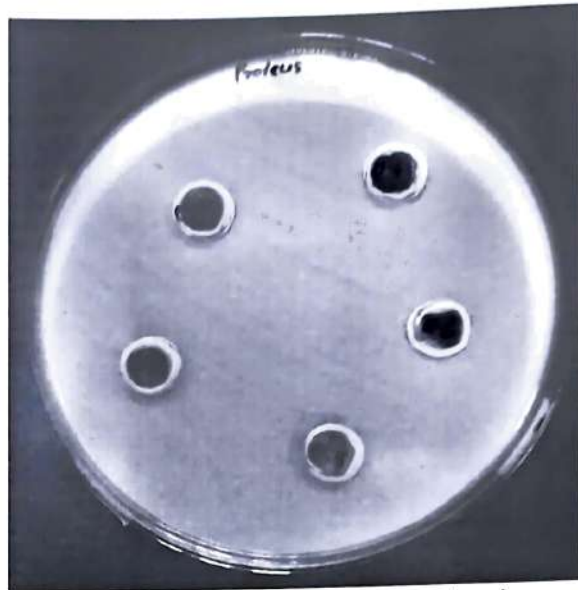
Fig.11: MBC of *Bacillus velezensis*Fig. 10: MIC of *Proteus vulgaris*

Table 2. Zone of inhibition (minimum inhibitory concentration)

Concentration (µg/ml)	Zone of inhibition (mm)	
	<i>Bacillus velezensis</i>	<i>Proteus vulgaris</i>
0.2	Nil	Nil
0.4	3 + 0.08	2 + 0.06
0.6	6 + 0.06	4 + 0.04
0.8	4 + 0.05	3 + 0.02
1	2 + 0.12	3 + 0.06

3.3 Antioxidant Activity of CuNPs: The DPPH scavenging activity of ascorbic acid is 35.5%, while that of CuNPs is 12.67%. In the FRAP assay, the reducing activity of ferric chloride was 79%, whereas that of CuNPs was 41%. In both methods, the CuNPs derived from *Centella asiatica* exhibited significant antioxidant activity when compared to the standards. Green synthesis studies of nano-particle synthesis are in progress, and further research is needed in this aspect.

CONCLUSION

Copper nanoparticles were synthesised using leaf extracts of *Centella asiatica*. Structural analysis was conducted using UV-visible spectroscopy and XRD. The synthesised nanoparticles demonstrated antibacterial activity against *Pseudomonas aeruginosa*, *Bacillus velezensis*, *Klebsiella ozaenae*, and *Proteus vulgaris* with inhibition zones of 16 ± 0.12 , 21 ± 0.29 , 11 ± 0.12 , and 20 ± 0.29 mm, respectively, surpassing the effectiveness of the positive control gentamycin. Copper nanoparticles also exhibited antioxidant activity, with a DPPH assay result of 12.67% and an FRAP-reducing activity of 41%. This study underscores the potential of medicinal plants for the synthesis of copper nanoparticles with robust antibacterial and antioxidant properties. Further investigations are necessary to identify the functional groups responsible for binding and stabilizing copper nanoparticles. Additionally, comparative studies with other metal nanoparticles in *Centella asiatica* leaf extracts could be conducted.

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