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REVIEW ARTICLE

EFFECT OF SEED TREATMENT AND GROWING CONDITIONS ON GERMINATION, GROWTH AND SURVIVAL OF INDIAN GOOSEBERRY SEEDLINGS (*EMBLICA OFFICINALIS GAERTN)*

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Abstract: The study was carried out at Fruit Research Station, Imaliya, Department of Horticulture, college of Agriculture, JNKVV, Jabalpur, (M.P.) during January 2018 to May 2018. The experiment consist of three growing conditions viz. (C_1) Open condition, (C_2) net house, (C_3) poly house condition and six treatments of seed i.e. (S_1) water soaking, (S_2) GA_3 200 ppm, (S_3) GA_3 400ppm, (S_4) GA_3 600ppm, (S_5) Thiourea 0.5%, and (S_6) Thiourea 1% having 18 treatment combinations. Among the growing conditions poly house and among the seed treatment, GA_3 (600ppm) were proved most promising as compare to others. Among the various treatment combination, the C_3S_4 treatment combination (poly house and 600 ppm GA_3) was proved most superior over rest of the treatment combinations with respect to germination parameters, growth parameters and survival parameter like days taken to start 1st germination (4.00), days taken to 50% germination (21.67), percentage of seeds germination (53.33%), (73.33%) and (73.33%) were noted at 20, 30, 40 days after sowing, height of shoots (4.38, 8.38, 29.05 and 35.14 cm), number of leaves per seedling (5.64, 33.33, 81.73 and 103.73), girth of stem (1.42, 1.53, 1.63 and 1.80 mm) at 30, 60, 90 and 120 DAS respectively and survival percentage 73.33 at 120 DAS.

Keywords: Indian gooseberry (*Emblica officinalis*)**,** GA_3**,** Thiourea, Growing, Poly house condition

INTRODUCTION

Aonla (*Emblica officinalis Gaertn*) also known as "Indian goose berry" belongs to family Euphorbiaceae. It is thought to be native of India, Ceylon, Malaysia and China. It thrives well thoughtout tropical India and is wild or cultivated in the region extending from the base of Himalaya to Ceylon, Malaysia to South China. In India, aonla occupies an area of 88,000 ha. with production of 9,72,000 MT. In M.P., the area under aonla is reported to be 14.85 thousand ha and production 187.07 thousand MT. (Anonymous, 2015-16). Aonla is a branched tree and ranges from 9-12 m in height. Aonla is hardy tree, prolific bearer, highly remunerative even without much care. It can be successfully cultivated in marginal soil and various kinds of wasteland situations such as sodic and saline soil, ravines, dry and semi dry regions including plateau area of central and southern India. Aonla acclaimed as ''Amrit phal'' in ayurveda and has acquired wide popularity all over the world due to its nutritional and medicinal importance.The aonla fruit is highly nutritive and is one of the richest sources of vitamin 'C. It contains 309.96 to 583.20 mg of ascorbic acid per 100 g of pulp (Supe *et al.*, 1997). The fruit is also rich in pectin and minerals such as iron, calcium and phosphorus. Aonla is acidic, cooling, diuretic and laxative. Hence, it has got great importance in preparation *of Ayurvedic* medicines. Aonla can be processed into many value added products i.e., murabba, candy, pickles, triphala churna as well as chyavanprash. Aonla can be propagated both by sexual and asexual methods. Sexually, it is propagated by seeds, however, being the cross pollinated crop, the variability does exist in the seedling population. Hence, seeds are only used for raising seedlings which are further used as rootstocks. As the area under aonla is increasing day by day, the demand of budded plants is also increasing but this demand is not fulfilled because of various factors like poor seed germination and poor seedling growth. The presence of impermeable seed coat acts as barrier to seed germination in aonla (Pawshe *et al.*, 1997). Pre-sowing seed treatments with chemicals like GA_3, Thiourea, KNO_3 and NAA have been reported to influence the duration of germination, per cent seed germination, seedling height, number of branches and roots (Dhankar and Singh, 1996; Pawshe *et al.*, 1997; Gholap *et al.*, 2000; Rajamanickam *et al.*, 2002).

MATERIALS AND METHODS

The present experiment *"*Effect of seed treatment and growing conditions on germination, growth and survival of Indian gooseberry seedling (*Emblica officinalis Gaertn)*" was carried out at Fruit Research Station, Imalia, Department of Horticulture, College of Agriculture, JNKVV, Jabalpur (M.P.) during January 2018 to May 2018. The experiment comprised of three growing conditions viz. (C_1) Open condition, (C_2) net house, (C_3) poly house condition and six treatments of seed i.e. (S_1) water soaking, (S_2) GA_3 200ppm, (S_3) GA_3 400ppm, (S_4) GA_3 600ppm, (S_5) Thiourea 0.5%, and (S_6) Thiourea 1% having 18 treatment combinations. The experiment was laid out in poly bags in factorial completely randomized design with three

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replications. Observations were recorded using standard procedure and statistically analyzed.

A. Germination Parameters

1. Days taken to start first germination – Date of emergence of cotyledonary leaves was recorded and calculated from date of sowing.

2. Days taken to 50% germination – The number of days were counted from the start germination till 50 % germination.

3. Percent of germination –The percentage of total seeds germination in each treatment was recorded at 20, 30, and 40 days after sowing.

$$\textbf{Germination (\%)} = \frac{\text{No. of germinating seed}}{\text{Total no. of seeds sown}} \times 100$$

B. Growth Parameter

The fallowing observations were recorded at 30, 60, 90 and 120 days after sowing. Randomly selected five plants were tagged for following observations.

1. Height of Seedling (cm) – Height was measured from ground level to the tip of opened leaf.

2. Girth of stem (mm) – The girth of stem was measured with the help of digital verneer calipers just above the ground surface and the average was calculated.

3. No. of branches per plant - The total number of branches per plant was counted and the average was calculated.

4. Number of leaves per seedling – The total number of leaves per seedling was counted and the average was calculated. Matured leaves were taken into account.

5. Survival percentage – The seeds survival percentage in each treatment was recorded at 120 days after sowing.

$$\textbf{Survival (\%)} = \frac{\text{No. of seedling survived}}{\text{Total no. of seedlings}} \times 100$$

RESULTS AND DISCUSSION

A- GERMINATION PARAMETERS

1- Days taken to start 1st germination-The result clearly showed that all the growing condition significantly affected the days taken to start germination. The minimum days (4.72) was recorded with growing condition C_3 (poly house condition) followed by C_2 (6.56) whereas, maximum days (9.44 days) were recorded under C_1.The data also indicates that the various seed treatment significantly influenced the days taken to start seed germination. The minimum days (6.33) was recorded with treatment S_4 (GA_3 600 ppm). The maximum days (7.67) were taken to start germination under S_1 (Control). The interaction effects of growing condition and seed treatments were found to have significant impact on germination. However, minimum days (4.00) taken to start germination was noted under the combination of C_3S_4 which was found statistically at par with C_3S_5 (4.33).This is due to high temperature and humidity in poly house coupled with GA_3 which initiated the early germination. Our results are also in the line of Singh *et al.* (2002), Dhankar and Singh (1996) Ratan and Reddy (2004).

2-The days taken to 50% germination- The data pertaining to days taken to 50% germination clearly showed that all the growing conditions significantly affected the days taken to 50% germination of seed over C_1 (control). C_3 (poly house) recorded minimum days (33.33) for 50% germination. The maximum days (53.06) to achieve 50% germination were noted under C_1 (open condition). The seed treatments also significantly influenced the germination. The days taken to 50% germination was observed minimum (37.22) in S_4 (GA_3 600 ppm) followed by S_5 (44.44 days) and maximum days (49.44) under S_1 (control). The interaction effect of growing condition and seed treatments were found to have significant effect. The minimum days (21.67) taken to 50% germination were found in C_3S_4 (poly house and GA_3 600 ppm). Our results are also in the line of Ynoue *et al.* (1999).

Table 1. (A) Effect of growing conditions and seed treatment on days taken to start 1st germination and 50% germination of aonla

	Treatments	Days taken to start 1st germination	Days taken to 50% germination
	Growing condition		
C_1	Open condition	9.44	53.06
C_2	Net house condition	6.56	46.94
C_3	Poly house condition	4.72	33.33
	S.Em±	0.07	0.11
	C.D.5% level	0.21	0.33
	Seed Treatment		
S_1	Water soaking	7.67	49.44

S_2	GA_3 200ppm	6.78	45.56
S_3	GA_3 400ppm	7.11	45.00
S_4	GA_3 600ppm	6.33	37.22
S_5	Thiourea 0.5%	6.67	44.44
S_6	Thiourea 1.0%	6.89	45.00
	S.Em±	0.10	0.16
	C.D.5% level	0.30	0.47
(B) Interaction effect of growing conditions and seed treatment on days taken to start 1st germination and 50% germination of aonla			
C_1S_1	Open condition+ Water soaking	10.33	56.67
C_1S_2	Open condition+ GA_3 200ppm	9.00	53.33
C_1S_3	Open condition+ GA_3 400ppm	9.33	51.67
C_1S_4	Open condition+ GA_3 600ppm	9.00	48.33
C_1S_5	Open condition+ Thiourea 0.5%	9.33	55.00
C_1S_6	Open condition+ Thiourea 1.0%	9.67	53.33
C_2S_1	Net house+ Water soaking	7.33	55.00
C_2S_2	Net house+ GA_3 200ppm	6.33	46.67
C_2S_3	Net house+ GA_3 400ppm	7.00	50.00
C_2S_4	Net house+ GA_3 600ppm	7.00	41.67
C_2S_5	Net house+ Thiourea 0.5%	5.33	43.33
C_2S_6	Net house+ Thiourea 1.0%	6.33	45.00
C_3S_1	Poly house+ Water soaking	5.33	36.67
C_3S_2	Poly house+ GA_3 200ppm	5.00	36.67
C_3S_3	Poly house+ GA_3 400ppm	5.00	33.33
C_3S_4	Poly house+ GA_3 600ppm	4.00	21.67
C_3S_5	Poly house+ Thiourea 0.5%	4.33	35.00
C_3S_6	Poly house+ Thiourea 1.0%	4.67	36.67
	S.Em±	0.18	0.28
	C.D.5% level	0.53	0.82

3-Percentage of germination at 20, 30 and 40 days after sowing (DAS)-Data revealed that almost all the condition showed significant effect on percentage of germination maximum percentage of seeds germination (31.67%), (49.44%) and (53.89%) were noted at 20, 30 and 40 days after sowing under C_3 (poly house condition) whereas, the minimum percentage of seeds germination (12.22%), (22.22%) and (23.89%) were noted under C_1 (open condition). The maximum percentage of seeds germination (31.11%), (45.56%) and (50.00%) were noted in seeds treated with S_4 (GA_3 600 ppm) at 20, 30 and 40 days after sowing, whereas, the minimum percentage of seeds germination (14.44%), (24.44%) and (26.67%) were noted in S_1 (control). The maximum percentage of seeds germination (53.33%), (73.33%) and (73.33%) were noted at 20, 30, 40 days after sowing under interaction of C_3S_4 (poly house

condition and GA_3 600 ppm) whereas, the minimum percentage of seeds germination (10.00%), (13.33%), (13.33%) were noted under C_1S_1 (open condition and control).It might be due to GA_3 which accelerate the activity of specific enzymes such as α-amylase, which have brought an increase in availability of starch assimilation resulting in an early germination. Our results are also in the line of Wagh *et al.* (1998), Dhankar *et al.* (1996, 1997) Pawshe *et al.* (1997).

Table 2. (A) Effect of growing conditions and seed treatment on percentage of germination of aonla

	Treatments	Percentage of germination		
		20 days	30 days	40 days
	Growing condition			
C_1	Open condition	12.22	22.22	23.89
C_2	Net house condition	17.78	27.78	33.89
C_3	Poly house condition	31.67	49.44	53.89
	S.Em±	0.56	0.24	0.10
	C.D.5% level	1.61	0.71	0.30
	Seed treatment			
S_1	Water soaking	14.44	24.44	26.67
S_2	GA_3 200ppm	20.00	31.11	34.44
S_3	GA_3 400ppm	18.89	34.44	37.78
S_4	GA_3 600ppm	31.11	45.56	50.00
S_5	Thiourea 0.5%	17.78	34.44	40.00
S_6	Thiourea 1.0%	21.11	28.89	34.44
	S.Em±	0.79	0.34	0.15
	C.D.5% level	2.28	1.00	0.43
(B) Interaction effect of growing conditions and seed treatment on percentage of germination of aonla				
C_1S_1	Open condition+ Water soaking	10.00	13.33	13.33
C_1S_2	Open condition+ GA_3 200ppm	10.00	20.00	20.00
C_1S_3	Open condition+ GA_3 400ppm	13.33	26.67	30.00
C_1S_4	Open condition+ GA_3 600ppm	16.67	30.00	33.33
C_1S_5	Open condition+ Thiourea 0.5%	13.33	26.67	30.00
C_1S_6	Open condition+ Thiourea 1.0%	10.00	16.67	16.67
C_2S_1	Net house+ Water soaking	13.33	20.00	23.33
C_2S_2	Net house+ GA_3 200ppm	20.00	30.00	33.33
C_2S_3	Net house+ GA_3 400ppm	16.67	30.00	30.00
C_2S_4	Net house+ GA_3 600ppm	23.33	33.33	43.33
C_2S_5	Net house+ Thiourea 0.5%	16.67	26.67	40.00
C_2S_6	Net house+ Thiourea 1.0%	16.67	26.67	33.33
C_3S_1	Poly house+ Water soaking	20.00	40.00	43.33
C_3S_2	Poly house+ GA_3 200ppm	30.00	43.33	50.00
C_3S_3	Poly house+ GA_3 400ppm	26.67	46.67	53.33
C_3S_4	Poly house+ GA_3 600ppm	53.33	73.33	73.33
C_3S_5	Poly house+ Thiourea 0.5%	23.33	50.00	50.00
C_3S_6	Poly house+ Thiourea 1.0%	36.67	43.33	53.33
	S.Em±	1.37	0.60	0.26
	C.D.5% level	3.95	1.73	0.75

Growth Parameter

1. Height of plants (cm) at 30, 60, 90 and 120 DAS

The data showed that almost all the growing conditions and treatments have significant effect on height of plant. The maximum plant height of 4.01, 7.92, 27.00 and 33.43 cm were noted under C_3 (poly house condition) at 30, 60, 90 and 120 DAS respectively. The minimum plant height 2.27, 4.66, 7.29 and 13.19 cm were recorded under C_1 (open condition) at 30, 60, 90 and 120 DAS. The maximum plant height of 3.99, 7.39, 16.77 and 27.39 cm were noted with S_4 (GA_3 600 ppm) at 30, 60, 90 and 120 DAS respectively and the minimum plant height 2.67, 5.67,14.12 and 25.08 cm were recorded in S_1 (control) at 30, 60, 90 and 120 DAS. The maximum plant height 4.38, 8.38, 29.05 and 35.14 cm were noted under C_3S_4 (poly house condition and GA_3 600 ppm) at 30, 60, 90 and 120 DAS, whereas, the minimum height 1.35, 3.92, 6.61 and 12.03 cm were recorded under in C_1S_1 (open condition and control). Our results are also in the line of Ngullie and Biswas (2017). Basically, plant height is a genetically controlled character but several studies have indicated that plant height can be increased by

application of synthetic plant growth regulators. However, in the present investigation, a significant difference in plant height was noticed by the application of different concentration of GA_3. It might be due to GA_3 effect on elongation of internodes, as GA_3 is known to enhance cell elongation. Our results are also in the line of Chandra and Govind (1990) and Singh *et al.* (2002), Pampanna *et al*. (1995).

Table 3. (A) Effect of growing conditions and seed treatment on height (cm) of aonla seedlings

	Treatments	**Height of seedlings (cm) at**			
		30 days	**60 days**	**90 days**	**120 days**
	Growing condition				
C_1	Open condition	2.27	4.66	7.29	13.19
C_2	Net house condition	3.64	6.76	13.08	31.59
C_3	Poly house condition	4.01	7.92	27.00	33.43
	S.Em±	0.008	0.009	0.24	0.09
	C.D.5% level	0.02	0.026	0.70	0.26
	Seed treatment				
S_1	Water soaking	2.67	5.67	14.12	25.08
S_2	GA_3 200ppm	3.17	6.74	16.12	26.45
S_3	GA_3 400ppm	2.98	6.12	15.90	26.30
S_4	GA_3 600ppm	3.99	7.39	16.77	27.39
S_5	Thiourea 0.5%	3.52	6.28	15.89	25.76
S_6	Thiourea 1.0%	3.50	6.49	15.94	25.44
	S.Em±	0.01	0.01	0.34	0.12
	C.D.5% level	0.03	0.03	0.99	0.36
(B) Interaction effect of growing conditions and seed treatment on height (cm) of aonla seedlings					
C_1S_1	Open condition+ Water soaking	1.35	3.92	6.61	12.03
C_1S_2	Open condition+ GA_3 200ppm	2.10	4.63	7.08	12.84
C_1S_3	Open condition+ GA_3 400ppm	1.50	4.13	7.43	13.84
C_1S_4	Open condition+ GA_3 600ppm	3.50	6.09	8.02	14.58
C_1S_5	Open condition+ Thiourea 0.5%	2.57	5.04	7.57	13.34
C_1S_6	Open condition+ Thiourea 1.0%	2.57	4.17	7.00	12.51
C_2S_1	Net house+ Water soaking	3.18	5.47	12.60	31.04
C_2S_2	Net house+ GA_3 200ppm	3.39	7.60	13.13	31.70
C_2S_3	Net house+ GA_3 400ppm	3.60	6.50	13.21	31.67
C_2S_4	Net house+ GA_3 600ppm	4.08	7.70	13.23	32.45
C_2S_5	Net house+ Thiourea 0.5%	3.67	6.13	13.17	31.48
C_2S_6	Net house+ Thiourea 1.0%	3.93	7.17	13.10	31.16
C_3S_1	Poly house+ Water soaking	3.48	7.63	23.14	32.18
C_3S_2	Poly house+ GA_3 200ppm	4.03	7.99	28.13	34.81

C_3S_3	Poly house+ GA_3 400ppm	3.83	7.72	27.06	33.38
C_3S_4	Poly house+ GA_3 600ppm	4.38	8.38	29.05	35.14
C_3S_5	Poly house+ Thiourea 0.5%	4.32	7.67	26.91	32.44
C_3S_6	Poly house+ Thiourea 1.0%	4.00	8.14	27.71	32.65
	S.Em±	0.02	0.02	0.59	0.22
	C.D.5% level	0.05	0.06	1.72	0.64

1. Girth of stem (mm) at 30, 60, 90 and 120 DAS

The maximum stem girth of 1.19, 1.43, 1.44 and 1.73 mm were noted under C_3 (poly house condition) at 30, 60, 90 and 120 DAS respectively. The minimum stem girth 1.05, 1.13, 1.43 and 1.71 mm were recorded under C_1 (open condition) at 30, 60, 90 and 120 DAS. The maximum stem girth of 1.27, 1.29, 1.54 and 1.76 mm were noted with S_4 (GA_3 600 ppm) at 30, 60, 90 and 120 DAS respectively. The minimum stem girth 0.97, 1.16, 1.34 and 1.61 mm were recorded in S_1 (control) at 30, 60, 90 and 120 DAS. The maximum stem girth 1.42 1.53, 1.63 and 1.80 mm were noted under C_3S_4 (poly house condition and GA_3 600 ppm) at 30, 60, 90 and 120 DAS and minimum were recorded under 0.95, 1.04, 1.21 and 1.52 mm in C_1S_1 (open condition and control). Our results are also in the line of Singh *et al.* (2004) and Meena and jain (2005).

Table 4. (A) Effect of growing conditions and seed treatment on girth of stem (mm) of aonla seedlings

Treatments		**Girth of stem (mm) at**			
		30 days	**60 Days**	**90 days**	**120 days**
	Growing conditions				
C_1	Open condition	1.05	1.13	1.43	1.71
C_2	Net house condition	1.10	1.10	1.43	1.63
C_3	Poly house condition	1.19	1.43	1.44	1.73
	S.Em±	0.01	0.006	0.001	0.001
	C.D.5% level	0.04	0.01	0.003	0.003
	Seed treatment				
S_1	Water soaking	0.97	1.16	1.34	1.61
S_2	GA_3 200ppm	1.05	1.18	1.44	1.68
S_3	GA_3 400ppm	1.16	1.20	1.40	1.71
S_4	GA_3 600ppm	1.27	1.29	1.54	1.76
S_5	Thiourea 0.5%	1.10	1.23	1.43	1.71
S_6	Thiourea 1.0%	1.12	1.25	1.44	1.68
	S.Em±	0.02	0.01	0.002	0.001
	C.D.5% level	0.06	0.03	0.005	0.004
(B) Interaction effect of growing conditions and seed treatment on girth of stem (mm) of aonla seedlings					
C_1S_1	Open condition+ Water soaking	0.95	1.04	1.21	1.52
C_1S_2	Open condition+ GA_3 200ppm	0.99	1.09	1.47	1.72
C_1S_3	Open condition+ GA_3 400ppm	1.03	1.13	1.40	1.74
C_1S_4	Open condition+ GA_3 600ppm	1.22	1.18	1.54	1.77
C_1S_5	Open condition+ Thiourea 0.5%	1.03	1.16	1.41	1.68

C_1S_6	Open condition+ Thiourea 1.0%	1.08	1.17	1.40	1.70
C_2S_1	Net house+ Water soaking	0.95	1.06	1.41	1.65
C_2S_2	Net house+ GA_3 200ppm	1.13	1.06	1.43	1.58
C_2S_3	Net house+ GA_3 400ppm	1.10	1.08	1.41	1.67
C_2S_4	Net house+ GA_3 600ppm	1.16	1.16	1.45	1.71
C_2S_5	Net house+ Thiourea 0.5%	1.15	1.14	1.43	1.70
C_2S_6	Net house+ Thiourea 1.0%	1.12	1.11	1.44	1.61
C_3S_1	Poly house+ Water soaking	1.02	1.38	1.38	1.65
C_3S_2	Poly house+ GA_3 200ppm	1.04	1.38	1.43	1.73
C_3S_3	Poly house+ GA_3 400ppm	1.34	1.39	1.40	1.71
C_3S_4	Poly house+ GA_3 600ppm	1.42	1.53	1.63	1.80
C_3S_5	Poly house+ Thiourea 0.5%	1.12	1.39	1.45	1.75
C_3S_6	Poly house+ Thiourea 1.0%	1.17	1.48	1.48	1.72
	S.Em±	0.03	0.01	0.003	0.002
	C.D.5% level	0.10	0.04	0.008	0.007

1. No. of branches / plant at 30, 60, 90 and 120 DAS

The maximum no. of branches /plant of 2.55, 6.32, 8.70 and 13.58 were noted under C_3 (poly house condition) at 30, 60, 90 and 120 DAS respectively. The minimum no. of branches / plant 2.04, 4.68, 6.65 and 9.44 were recorded under C_1 (open condition) at 30, 60, 90 and 120 DAS. The maximum no. of branches / plant of 2.55, 5.88 statistically at par with S_5 (5.83) at 60 days, 8.03 and 13.01 were noted with S_4 (GA_3 600 ppm) at 30, 60, 90 and 120 DAS respectively. The minimum no. of branches / plant 1.91, 4.94, 7.18 and 11.30 were recorded in S_1 (control) at 30, 60, 90 and 120 DAS. The maximum no. of branches / plant 2.82 statistically at par with C_3S_5 (2.76), C_3S_2 (2.66) at 30 days, 7.04 statistically at par with C_3S_5 (6.98) at 60 days, 9.53 and 13.97 statistically at par with C_3S_5 (13.73), C_3S_2 (13.90), C_2S_6 (13.670, C_2S_4 (13.87) at 120 days were noted under C_3S_4 (poly house condition and GA_3 600 ppm) at 30, 60, 90 and 120 DAS and minimum 1.42, 4.27, 6.40 and 8.73 were recorded under in C_1S_1 (open condition and control).

Table 5. (A) Effect of growing conditions and seed treatment on number of branches /plant of aonla seedlings

	Treatments	**No. of branches /plant at**			
		30 days	**60 days**	**90 days**	**120 days**
	Growing conditions				
C_1	Open condition	2.04	4.68	6.65	9.44
C_2	Net house condition	2.28	5.41	7.43	13.43
C_3	Poly house condition	2.55	6.32	8.70	13.58
	S.Em±	0.04	0.03	0.06	0.04
	C.D.5% level	0.11	0.09	0.18	0.12
	Seed treatment				
S_1	Water soaking	1.91	4.94	7.18	11.30
S_2	GA_3 200ppm	2.22	5.30	7.66	12.41
S_3	GA_3 400ppm	2.38	5.33	7.44	11.89

S_4	GA_3 600ppm	2.55	5.88	8.03	13.01
S_5	Thiourea 0.5%	2.38	5.83	7.64	12.09
S_6	Thiourea 1.0%	2.28	5.53	7.60	12.21
	S.Em±	0.05	0.05	0.09	0.06
	C.D.5% level	0.16	0.14	0.27	0.18
(B) Interaction effect of growing conditions and seed treatment on number of branches /plant of aonla seedlings					
C_1S_1	Open condition+ Water soaking	1.42	4.27	6.40	8.73
C_1S_2	Open condition+ GA_3 200ppm	1.92	4.33	6.73	10.00
C_1S_3	Open condition+ GA_3 400ppm	2.22	4.80	6.67	8.93
C_1S_4	Open condition+ GA_3 600ppm	2.33	4.97	6.77	11.20
C_1S_5	Open condition+ Thiourea 0.5%	2.16	4.92	6.73	9.00
C_1S_6	Open condition+ Thiourea 1.0%	2.17	4.80	6.60	8.77
C_2S_1	Net house+ Water soaking	2.04	5.07	7.07	12.93
C_2S_2	Net house+ GA_3 200ppm	2.09	5.37	7.37	13.33
C_2S_3	Net house+ GA_3 400ppm	2.48	5.60	7.53	13.27
C_2S_4	Net house+ GA_3 600ppm	2.50	5.62	7.80	13.87
C_2S_5	Net house+ Thiourea 0.5%	2.27	5.58	7.53	13.53
C_2S_6	Net house+ Thiourea 1.0%	2.31	5.20	7.27	13.67
C_3S_1	Poly house+ Water soaking	2.28	5.48	8.07	12.23
C_3S_2	Poly house+ GA_3 200ppm	2.66	6.20	8.87	13.90
C_3S_3	Poly house+ GA_3 400ppm	2.45	5.60	8.13	13.47
C_3S_4	Poly house+ GA_3 600ppm	2.82	7.04	9.53	13.97
C_3S_5	Poly house+ Thiourea 0.5%	2.76	6.98	8.67	13.73
C_3S_6	Poly house+ Thiourea 1.0%	2.37	6.60	8.93	13.20
	S.Em±	0.09	0.08	0.15	0.11
	C.D.5% level	0.27	0.24	0.45	0.32

1. Number of leaves at 30, 60, 90 and 120 DAS

The maximum number of leaves 5.04, 29.19, 77.47 and 100.71 were noted under C_3 (Poly house condition) at 30, 60, 90, 120 DAS, respectively. The minimum no. of leaves of 3.97, 12.83, 34.16 and 68.03 leaves were recorded under C_1 (Open condition) at 30, 60, 90 and 120 DAS respectively. The maximum number of leaves 5.10, 21.72, 64.42 and 92.97 were noted under S_4 (GA_3 600 ppm) at 30, 60, 90 and 120 DAS, respectively. The minimum no. of leaves of 3.80, 17.22, 58.81 and 87.39 leaves were recorded under S_1 (control) at 30, 60, 90 and 120 DAS respectively. The maximum no. of leaves 5.64 statistically at par with C_3S_5 (5.55) at 30 days, 33.33, 81.73, 103.73 were noted under C_3S_4 (poly house condition and GA_3 600 ppm) at 30, 60, 90, 120 DAS. However, the minimum 2.83, 10.65, 32.40, 64.73 leaves were recorded under C_1S_1 (open condition and control). The production of more number of leaves in GA_3 treatments may be due to the vigorous growth and more number of branches induced by GA_3 which facilitates better harvest of sunshine by the plants to produce more number of leaves. Similar findings were also reported by Chandore *et al* (2016), Thamer HR and AL Falahy (2014).

Table 6. (A) Effect of growing conditions and seed treatment on number of leaves /seedling of aonla seedlings

	Treatments	No. of leaves /seedling at			
		30 days	60 days	90 days	120 days
	Growing condition				
C_1	Open condition	3.97	12.83	34.16	68.03
C_2	Net house condition	4.49	15.67	72.82	100.44
C_3	Poly house condition	5.04	29.19	77.47	100.71
	S.Em±	0.01	0.05	0.29	0.02
	C.D.5% level	0.04	0.15	0.85	0.06
	Seed treatment				
S_1	Water soaking	3.80	17.22	58.81	87.39
S_2	GA_3 200ppm	4.38	18.16	60.93	90.12
S_3	GA_3 400ppm	4.72	18.84	62.09	89.97
S_4	GA_3 600ppm	5.10	21.72	64.42	92.97
S_5	Thiourea 0.5%	4.55	19.56	61.87	89.32
S_6	Thiourea 1.0%	4.43	19.88	60.78	88.60
	S.Em±	0.02	0.07	0.41	0.03
	C.D.5% level	0.06	0.21	1.19	0.09
(B) Interaction effect of growing conditions and seed treatment on number of leaves /seedling of aonla seedlings					
C_1S_1	Open condition+ Water soaking	2.83	10.65	32.40	64.73
C_1S_2	Open condition+ GA_3 200ppm	3.83	11.60	32.60	69.30
C_1S_3	Open condition+ GA_3 400ppm	4.58	12.53	33.93	68.33
C_1S_4	Open condition+ GA_3 600ppm	4.67	14.88	36.13	72.40
C_1S_5	Open condition+ Thiourea 0.5%	3.89	14.52	34.33	66.57
C_1S_6	Open condition+ Thiourea 1.0%	4.00	12.80	35.53	66.83
C_2S_1	Net house+ Water soaking	4.00	14.40	68.40	99.20
C_2S_2	Net house+ GA_3 200ppm	4.22	14.68	73.40	100.60
C_2S_3	Net house+ GA_3 400ppm	4.77	15.73	74.27	100.53
C_2S_4	Net house+ GA_3 600ppm	5.00	16.93	75.40	103.07
C_2S_5	Net house+ Thiourea 0.5%	4.20	16.87	74.33	100.67
C_2S_6	Net house+ Thiourea 1.0%	4.73	15.40	71.13	100.20
C_3S_1	Poly house+ Water soaking	4.55	26.60	75.63	98.23
C_3S_2	Poly house+ GA_3 200ppm	5.08	28.20	76.80	100.47
C_3S_3	Poly house+ GA_3 400ppm	4.82	28.25	78.07	101.03
C_3S_4	Poly house+ GA_3 600ppm	5.64	33.33	81.73	103.73
C_3S_5	Poly house+ Thiourea 0.5%	5.55	27.31	76.93	100.43
C_3S_6	Poly house+ Thiourea 1.0%	4.57	31.44	75.67	98.77
	S.Em±	0.03	0.12	0.72	0.05
	C.D.5% level	0.10	0.36	2.08	0.16

1. Survival Percentage (%)

The data revealed that growing conditions and seed treatments significantly influenced the survival percentage of seedling at 120 DAS. The maximum survival percentage of 65.00 was recorded under C_3 (poly house) whereas, minimum percentage (60.00) was noted under C_2 (net house). The maximum survival percentage (70.00) was recorded with S_4 (GA_3 600 ppm) and minimum (54.44) under S_1 (control) at 120 days after seed sowing. Maximum survival percentage 73.33 was recorded under C_3S_4 (poly house and GA_3 600 ppm) and it was minimum 50.00 under C_2S_1 (net house condition and control). These findings are supported by Jain *et al.* (2017). It may be due to synergistic effect of both factors.

Table 7. (A) Effect of growing conditions and seed treatment on aonla seedlings

	Treatments	Survival (%)
	Growing condition	
C_1	Open condition	61.11

C_2	Net house condition	60.00
C_3	Poly house condition	65.00
	S.Em±	0.57
	C.D.5% level	1.66
	Seed treatment	
S_1	Water soaking	54.44
S_2	GA_3 200ppm	60.00
S_3	GA_3 400ppm	60.00
S_4	GA_3 600ppm	70.00
S_5	Thiourea 0.5%	62.22
S_6	Thiourea 1.0%	65.56
	S.Em±	0.81
	C.D.5% level	2.35
(B) Interaction effect of growing conditions and seed treatment on aonla seedlings		
C_1S_1	Open condition+ Water soaking	56.67
C_1S_2	Open condition+ GA_3 200ppm	60.00
C_1S_3	Open condition+ GA_3 400ppm	60.00
C_1S_4	Open condition+ GA_3 600ppm	66.67
C_1S_5	Open condition+ Thiourea 0.5%	60.00
C_1S_6	Open condition+ Thiourea 1.0%	63.33
C_2S_1	Net house+ Water soaking	50.00
C_2S_2	Net house+ GA_3 200ppm	60.00
C_2S_3	Net house+ GA_3 400ppm	53.33
C_2S_4	Net house+ GA_3 600ppm	70.00
C_2S_5	Net house+ Thiourea 0.5%	63.33
C_2S_6	Net house+ Thiourea 1.0%	63.33
C_3S_1	Poly house+ Water soaking	56.67
C_3S_2	Poly house+ GA_3 200ppm	60.00
C_3S_3	Poly house+ GA_3 400ppm	66.67
C_3S_4	Poly house+ GA_3 600ppm	73.33
C_3S_5	Poly house+ Thiourea 0.5%	63.33
C_3S_6	Poly house+ Thiourea 1.0%	70.00
	S.Em±	1.41
	C.D.5% level	4.07

CONCLUSION

On the basis of present investigation, it is concluded that among the various treatment combinations, C_3S_4 treatment combination (poly house and 600 ppm GA_3) proved superior to rest of the treatment combinations with respect to germination parameters, growth parameters and survival parameter like Days taken to start 1st germination, days taken to 50% germination, percentage of seeds

germination, height of shoots, girth of stem, number of leaves per seedling and Survival percentage (%). However, among the growing conditions poly house and among the seed treatment GA_3 (600ppm) were proved most promising as compare to others.

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REVIEW ARTICLE

DIFFERENT SYSTEM OF HYBRID DEVELOPMENT IN OKRA AND CUCURBITACEOUS VEGETABLES

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Abstract: Okra (*Abelmoschus esculentus*) is a monotypic genus under the family Malvaceae having a significant place in the Indian vegetable market and export market. Cucurbitaceae is the largest family of vegetable crops consisting of about 800 species in around 130 genera with dominance in production and consumption among Indian people. In both of the above vegetable families several hybrids have been developed which played a major role in increasing the area and production of these crops. Heterosis or hybrid vigour has been exploited in its full potential in several vegetables of these two vegetable families. Presence of Genetic male sterility (GMS) in okra and gynoecy, monoecy and dioecy in cucurbits has been provided a convenient and cost-effective method of mass hybrid seed production in those crops. Here we have discussed several hybrids developed and their method of development in okra and major cucurbits like cucumber, bitter gourd, bottle gourd, musk melon, pumpkin, sponge gourd, squashes and water melon.

Keywords: Cucurbits, Hybrid, Male sterility, Okra, Vegetable

INTRODUCTION

Due to ever-increasing demand of vegetables, the use of hybrids become popular to full fill the recommended consumption level of 300g vegetables per capita per day. The introduction of hybrids in public and private sector has greatly contributed to the vegetable production in our country. In most of vegetable crops the open pollinated varieties are being replaced by the hybrids. Hybrid varieties play a vital role in increasing vegetable production due to their high yield potential, early maturing, superior quality, disease and pest resistance attributes.

Different ICAR research institutes have contributed considerably to develop hybrid varieties. In India, more than 100 hybrid varieties of 15 vegetables have been developed in the public sector. The private seed companies have done commendable work in popularizing the hybrid varieties in India.

High cost of F1 hybrid seed is one of the major handicaps of successful hybrid vegetable technology. This is because under-utilization of available genetic tools for economic F1 seed production. In the entire country, mostly hand emasculation and hand pollination technique are being followed (with very little exception) to develop F1 hybrid seeds in most of vegetable crops.

Only about 10 per cent of vegetable area is under hybrids, of which tomatoes cover 36 per cent, cabbage 30 per cent, brinjal 18 per cent, okra 7 per cent, melons and gourds 5 per cent each, cauliflower 2 per cent and chilli 1 per cent. With awareness of advantages for cultivation of F1 hybrids, the area is bound to extend (Singh, 2004).

Hybrid development in okra

Okra has hermaphrodite flowers and often-cross-pollinated crop. Hybrid vigor is exploited in this crop. 60 % increased yield by Joshi *et al*., (1958). Hybrids developed by hand emasculation & pollination as no pollination control mechanisms were available earlier. 30-76 % heterosis for earliness, yield, no. of fruit/plant and fruit length. F_1 hybrids resistant to YVMV.

IARI, New Delhi

Pusa Sawani –IC-1542 X Pusa Makhmali. Developed through pedigree selection for YVMV resistance but later it became susceptible.

DOH-2, DOH-4 & DOH-6

IIHR, Bengaluru

Arka Anamika & **Arka Abhay** (Dutta & Singh, 1990) *A. esculentus* (IIHR 20-31) X *A. tetraphyllus var tetraphyllus* followed by back cross. Resistant to YVMV.

IIVR, Varanasi

Kashi Mahima (DVR-4) - resistant to YVMV & OLCV.

OTHERS SAUs

Manjima – released from KAU, Trissur (2006). (Gowreesapattom local X NBPGR/TCR-874). High yielding (16t/ha), early maturing, YVM resistant variety.

Punjab 7: *A. esculentus* (Pusa sawani) X *A. caillei* followed by backcross with Pusa sawani. Released from PAU by Harbajan Singh (1952).

Panjab Padmini: *A. esculentus* (Reshmi) X *A. caillei.* Released from PAU (Thakur and Arora 1986)

Parbhani Kranti: *A. esculentus* (Pusa sawani) X *A. manihot.* Released from Parbhani. (Jambhale & Nerkar, 1986)

Hyb-7 & 8 (TNAU)

GOH-3 & 4 (Gujarat AU)

*Corresponding Author

Hybrid released from Private sectors tolerant to YVMV

Sl. No.	Name of the varieties	Sources
1.	Sarika, Sonal, Shakthi	Nunhems
2.	Varsha, Vijay and Vishal	IAHS seeds
3.	No-10, No- 64	Mahyco seeds
4.	NS-811, NS-810, NS-801, 866	Namdhari seeds
5.	US -7109	US agri seeds
6.	Mona, Teja	Adventa seeds
7.	Avanthika	Bio-seed

Emasculation & pollination by hand may not be an economic proposition due to less number of seeds per fruit. Use of male sterility will be effective for commercial hybrid seed production.

Male sterility controlled by Single recessive gene in homozygous condition. stable and not influenced by the environmental factors. (ms1 and ms2). It can be induced by Gamma rays (500-600 Gy) and maintained by sib matting (Pitchaimuthu *et al*., 2012).

Arka Nikita - GMS-4 X IIIHR-299-14-11-585. It is developed using GMS line.

It has been identified for release by the Institute VTIC during 2017. Produces dark green, medium, smooth and tender fruits. Excellent cooking quality, nutritionally rich in antioxidant activity, high mucilage content (1.08 % (FW) and high edible fiber content (8.85 % (DW). It is rich in minerals like potassium (3.7 %), calcium 997 mg /100 g) and magnesium. Rich in iodine content (33.31µ g/kg). Yields 21-24 t/ha in 125 -130 days duration.

Hybrid development in cucurbits

Large and diverse group of vegetable crops in the family cucurbitaceae. Consists of 130 genera & 800 species (Jeffrey, 2005). Cross pollinated crops, no inbreeding depression. Significant heterosis in desirable directions for yield and yield attributed traits like sex ratio, days to first picking, number of fruits per plant, yield per plant and vine length have been reported in these crops.

Hybridization is relatively easier due to presence of big size of flowers and production of separate male and female flower in monoecious, dioecious plants and only female flower in gynoecious plants. No need of emasculation, male flower can be pinched off.

Sex Forms in Cucurbits

SEX FORMS	CUCURBITS
Monoecious	Cucumber, Musk melon, Pumpkin, Summer squash, Winter squash, water melon, Sponge gourd, Round melon, Bottle gourd, Bitter gourd
Gynoecious	Cucumber, Bitter gourd, Musk melon, Watermelon, Ridge gourd
Androecious	Cucumber, Musk melon
Dioecious	Pointed gourd, Ivy gourd,
Andromonoecious	Water melon, Musk melon
Gynomonoecious	Cucumber, Musk melon, Ridge gourd
Trimonoecious	Cucumber
Hermaphrodite	Satputia (Ridge gourd), Cucumber

(Genetics, Genomics and Breeding of Cucurbits, 2011)

These sex forms are interchangeable with application of growth regulators. Male sterility reported in musk melon and ridge gourd. These systems can aid the hybrid seed production in different cucurbits.

Hybrid seed production mechanism

The manual pollination method of seed production on commercial scale is only feasible in the development of hybrids of vegetables like tomato, eggplant, and cucurbits (bottle gourd, watermelon, pumpkin etc.) where large number of F_1 seeds can be obtained per pollination.

The hybrid seeds of bottle gourd, bitter gourd and pumpkin through protection of female flower and hand pollination (Flemine, 2010; Jat, 2011; Behera *et. al*, 2015); cucumber through natural pollination in case of gynoceious seed parent (Munshi *et al*., 2015)

The hybrids of cucumber are produced mainly by crossing gynoecious lines with monoecious lines. The other systems of producing gynoecious hybrid seed are gynoecious × gynoecious but gynoecious × monoecious hybrids are still widely grown hybrids because this offers advantages like earliness, high degree of female sex expression, with uniform and concentrated fruit formation, which was especially advantageous for mechanical harvest.

Ethrel 200-300 ppm at two and four true leaf stage and another at flowering is useful for inducing the pistilate flower in bottle gourd, pumpkin and squash for F1 seed production. The row of male parent is

grown side by the side of female and natural cross pollination is allowed.

Different methods of hybrid development in cucurbits are -

Pinching of staminate flowers and hand pollination – Bitter gourd, bottle gourd, pumpkin, watermelon and muskmelon

GMS + bee pollination – Musk melon

CGMS + natural pollination – Ridge gourd

Gynocecism and natural pollination – Cucumber, bitter gourd

PGR and natural pollination – Squash

Emasculation and hand pollination – Satputia – ridge gourd

Male msterility in cucurbits

Crop	Salient features of male sterility
Watermelon	Recessive mutant has been reported; linkage of ms gene with delayed-green (dg) seedling marker gene. MSDG-1 and MSDG-2 - Male sterile lines with delayed green seedling marker (Zhang et al., 1996) 93JMSB-1, 93JMSB-1-1, and 93JMSF3-2- male sterile lines with Juvenile albino seedlings. (Zhang *et al*., 1996)
Muskmelon	5 Recessive non-allelic genes have been reported; ms-1 is commercially utilized. linkage of ms 1 gene with red stem and ms 2 with yellow green leaf.
Cucumber	Monogenic recessive gene has been reported; limited scope of utilization because of the availability of gynoecious lines.
Ridge gourd	cytoplasmic male sterility with two dominant male fertility restorer nuclear genes
Summer squash	Monogenic recessive gene has been reported; very limited scope of utilization because of the availability of sex regulating mechanism using PGR, particularly ethephon.

Male sterility in Ridge gourd

Male sterile lines in Ridge gourd- IIHRRGMS-1 & IIHRRGMS-2. Rudimentary male flowers which do not open. Pollen sterility and no fruit set on selfing, if male flower is opened. Male sterile flower buds are smaller in size compared to the male fertile lines. Crosses were made with RGGP-4, RGGP-5 & RGGP-6. All F1 plants were male sterile in MS x RGGP-5 and RGGP-6 - Cytoplasmic male sterility-recessive gene control. In MS x RGGP-4: 16% male fertile.

Back-cross populations/F2 populations are developed to find out the genetics of inheritance of male sterility. Efforts are under way to identify the restorer lines - two dominant restorer genes were identified in ridge gourd. (Pradeep kumar *et al*., 2012)

These male sterile lines can be used for hybrid seed production.

Gynoecious lines reported in cucurbits for hybreed seed production (HSP)

Crop	Salient features of Gynoecious lines
Cucumber	Shogoin (PI-220860) Peterson and Anhder (1960) DCH-1, DCH-2 – Tropical gynoecious lines identified in IARI. Gyc- 1, Gyc-2, Gyc-3 - gynoecious lines identified in IARI Gyc - pkg-1 - gynoecious parthenocarpic line identified in MPKV, Rahuri.
Summer squash	NJ-34 – gynoecious line. It carries gene B for precocious fruit pigmentation.
Bitter gourd	Gy 263 B- Ram *et al.* (2002) DBGy-201, DBGy-202 Behera *et al*., (2006) IIHRBTGy-491 and IIHRBTGy-492 Varalakshmi *et al.* (2014)

Muskmelon	Wisconsin 998 (WI 998) Peterson *et al*., 1983 86-104, 105, 118 More *et a*l., 1987 GH 3-2, 5E-1, 7-7, 4D, 5D, 6C-4 and 6E-7 - More *et al*., 1991

1. HYBRIDS IN CUCUMBER

IARI, New Delhi

Pusa Sanyog – Japanese Gynoecious line X Green Long Naples. High yielding, fruits are 28-30 cm long, dark green with yellow stripes, matures in 50 days.

OTHER SAUs

Solan Khira Hybrid 1 – 1983 G X K90. Gynoecious based early maturing F1 hybrid, bears 10-12 cm long fruits, ready for harvesting in 65 days, yields 30-40 t/ha.

Solan Khira Hybrid 2 – 2780G X K90. Gynoecious based F1 hybrid, vines reach up to 5 m with 4-5 lateral branches, and fruits are cylindrical, 20-23 cm in length, black spine. Average yield 55-60 t/ha. Suitable for low temperature areas.

Public and private sector hybrids in cucumber

Crops	Hybrids	Source
Public sectors	Pusa Sanyog PCUCH-1 AAUC-1, AAUC-2 Solan Khira Hybrid 1, 2& KH-1 Phule Prachi Pant Shankar Khira-1 Harith and Shubra	IARI, New Delhi GBPUAT, pant Nagar AAU, Assam UHF, Solan MPKV, Rahuri GBPUAT, pant Nagar KAU, Trissur
Private seed companies	Priya Superior Slicer Liberty Aman Malini	Mahyco IAHS Suttons PROAGRO Seminis

2. HYBRIDS IN WATERMELON

IARI, New Delhi

Pusa Bedna – Tetra-2 X Pusa Rasal. Triploid seedless hybrid.

IIHR, Bengaluru

Arka Jyoti – IIHR.20 X Crimson Sweet. Released from IIHR, Bengaluru.

Arka Manik – IIHR.21 X Crimson Sweet. Resistant to powdery mildew, Downey mildew and anthracnose.

Arka Madhura - Triploid seedless watermelon variety. High yield 50-60 t/ha, T.S.S 13-14 %. Unique type, sweet, juicy and fully seedless. Longer shelf life and transport quality. Suitable for year-round production under protected condition.

Arka Akash - High yielding F1hybrid. Dark green with light green broken specks slightly deep foliage, oblong fruit red flesh, with TSS of 12-13% (brix), average fruit weight 6.5kg.

Arka Aiswarya - Green with Dark green deeply lobbed foliage, round to oval fruit, Dark green with light green broken stripes, red flesh, with TSS of 13-14% (brix), average fruit weight 7.5kg with 1-2 fruit per vine. Duration 95-100 days. Fruit yield 75 to 80 t/ha.

Other SAUs

Shonima – KAU, 2015. Red fleshed seedless triploid hybrid, rind colour is dark green with light green stripes. Avg wt is 3.92 kg.

Swarna – KAU, 2015. Bright Yellow fleshed seedless triploid hybrid, rind colour is green with yellow stripes. Avg wt is 3.18 kg.

HYBRIDS IN MUSKMELON

IARI, New Delhi

Pusa Rasraj – Monoecious - 3 × Durgapura Madhu. Monoecious based hybrid, developed from IARI. Fruits have 11-120 B TSS. Suitable for both garden and riverbeds. Yields 25 tonnes/ha.

Other SAUs

MHY-10 – gynoecious based hybrid

Punjab Hybrid – ms -1 × Hara Madhu. Male sterility-based hybrid using ms-1, developed from PAU. Early maturing with orange flesh and netted skin. Suitable for long distance transportation.

Punjab Anmol – ms -1 × Punjab Sunheri. Male sterility-based hybrid using ms-1, developed from PAU. It takes 70 days from transplanting to first picking. The fruit is oval-round, light brown, non-sutured and intensely netted. Flesh is thick, orange coloured, medium in juiciness and flavoursome with TSS content of 11.5 per cent. The fruits develop "full slip" stage. The average fruit weight is 7109. Fruits have better shelf life and are suitable for distant transportation.

HYBRIDS IN BITTER GOURD

IARI, New Delhi

Pusa Hybrid-1 IARI, New Delhi

Pusa Hybrid-2 IARI, New Delhi

Pusa Hybrid-4 - First gynoecious based bitter gourd hybrid developed by ICAR- IARI, New Delhi and released in 2018, for commercial cultivation. It has predominately gynoecious habit with high female: male flower ratio (2:1). Fruits are dark green, medium long and medium thick with 5-6 dis-continuous narrow ridges and first harvest after 45-50 days of sowing. The average fruit weight is 60g and its average yield is 22.26 t/ha.

Other SAUs

COBgoH.1 – It is a hybrid between MC.84 x MDU.1 from TNAU. Yield potential is 52 tonnes/ha in a crop duration of 115 -120 days. Fruits have high momordicin content (2.99mg/g). Fruits are white in colour.

Private organisations

Indam Kohinoor - released by Indo-American hybrid Seed Company. Vigorous plants, can withstand heat, wider adaptability, Green fruits, tubercles, length-17cm and 4.3cm diameter, good for transport, shiny 90-100gm fruits, high yielding with heat set. Matures in 50-55days after sowing, can be maintained up to 180days.

From World Vegetable centre – Taiwan, bitter gourd hybrid AVBG1601 (released as '**NBH-Figo**' by Noble Seeds Pvt. Ltd). This hybrid is high yielding, powdery mildew and virus tolerant.

HYBRIDS IN BOTTLE GOURD

IARI, New Delhi

Pusa Meghdoot - PSP Long × Sel. 2 Relatively early, fruits are long, light green and attractive. Suitable for cultivation in spring summer season.

Pusa Manjari - PSP Round × Sel. 11 It recorded 48% higher early yield and 106% total yield over PSP Round.

Pusa Hybrid-3

IIVR, Varanasi

Kashi Bahar – Straight fruit light green colour, medium size, 10-12 fruits per plant, 800-900 g fruit weight.

Other SAUs

Gujarat Anand Bottle Gourd Hybrid-1 (**GABGH-1**) - 2017 AAU, Anand - The fruits are medium in size and cylinder in shape with attractive light green colour.

Pant Sankar Lauki -1 - GBPUAT, Pantnagar.

Narendra Sankar-1 - NDUAT, Faizabad

HYBRIDS IN RIDGE GOURD

IIHR, Bengaluru

Arka Vikram - This hybrid has been identified for release by the institute VTIC during 2016. It takes 40 days for the first female flower appearance and 46 days for first picking of fruits produces green, long, tender fruits. Excellent cooking quality, nutritionally rich in antioxidant activity and minerals like potassium, calcium, iron, zinc and manganese. Yields 34.0 t/ha in 120-135 days duration.

HYBRIDS IN PUMPKIN

IARI, New Delhi

Pusa Hybrid-1 – high yielding, suitable for growing in both summer and kharif season.

HYBRIDS IN ASH GOURD

IARI, New Delhi

Pusa Shreyali - released in 2016 for commercial cultivation.

Pusa Urmi – is an excellent variety for commercial cultivation

HYBRIDS IN SUMMER SQUASH

IARI, New Delhi

Pusa Alankar - EC 207050 × Sel. 1. Developed from IARI, New Delhi. Green fruits with light coloured stripes, early maturing in 45 -50 days. Yields 20-30 tonnes/ha.

Diseases Resistance Hybrids of Different Vegetable Crops (Private Seed Companies)

Okra YVMV - No.7, No.8, No.10, Panchalik, Adhunik, Tara, Supriya, Uphar, Varsha, Vijay, Vishal

Ridge gourd Powdery mildew – Surekha

Watermelon Fusarium wilt – Amrit, MHW-6

Muskmelon Downey mildew – Madhuma

Future Strategies

To increase vegetable production not only to meet requirement of population but also increase per capita income of marginal farmers. The public and private sectors should exchange the inbred lines in liberal way to develop elite hybrids and their seed multiplication at cheap rate. The Govt. should support financially to the SAUs/ Institutions/vegetable growers to strengthen teaching, research and extension activities. Application of biotechnological approaches for production of high yielding and disease resistant hybrid vegetables.

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RESEARCH ARTICLE

STUDIES ON INDIGENOUS COW (*BOSINDICUS*) BASED BIO-ORGANIC FORMULATIONS (BOFS) IN TOMATO CULTIVATION FOR INCREASING SOIL HEALTH STIPULATION

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Abstract: India harvests a large variety of food crops including vegetables, cereals, pulses, oilseeds etc. In the name of increased productivity, unselective application of vast quantity of chemical fertilizers is being encouraged which is health deathtrap. Hence, an organic method of farming is of vital need which could satisfy the increased demand of food production as well as can provide a security against any possible health problem. In present study, a single transplanted plant per pot was elevated with manual and natural irrigation in environmental condition. The result showed that the plant enactment with respect to biomass components such as number of fruits, fruits weight, fresh shoot and root weight, dry shoot and root weight, shoot length and plant height were expressively influenced by used bio-organic formulations. The total plant biomass was found to be higher with application of Dasha Parni Extract (DPE, 45 ml/plant), Leaf Extract of *Azadirachta indica* (LEAI, 50ml/plant) and *Azadirachta Capsicum Alliums* Extract (ACAE, 55 ml/plant) as compared to combination of aforesaid bio-organic formulations. Similar trend was noticed with respect to fruit weight and plant height which were found to be significantly higher 83gm and 50cm respectively when plant treated with 55ml/plant dosage,65gm and 35cm respectively with 50 ml/plant dosage and 91gm and 43cm respectively when treated with 45 ml/plant dosage. Thus, based on this study, it may be concluded that method used for the production of tomato with the help of Bio-organic formulations (BOFs) as organic supplements, when implemented, can be effective, economical and eco-friendly method for production of various agriculture crops by farmers.

Keywords: *Bos indicus*, Bio-organic Formulations, Tomato, Soil health stipulation

INTRODUCTION

Organic standards include a well-defined set of practices and a list of technical tools that are permitted by regulations (*i.e.*, Reg no.889/08 in UE and the National Organic Program in U.S). A diet based on organic products claims to provide health benefits due to the higher concentration of nutritional compounds compared to conventional ones, and the absence of pesticide residues (Oates L.*et al.*, 2014). The present challenge of feeding the world requires new strategies to ensure food security, which is surely based on food availability and access, but also on food safety and nutritional quality. Organic production systems may be a way to ensure the sustainability of production, allowing preservation of natural resources for present and future generations, while providing a high quality and long shelf life of the product (Rembiałkowska, 2007). Agriculture plays a vital role in developing country like India. Apart from fulfilling the food requirement of the growing Indian population, it also plays a role in improving economy of the country.

Bio-organic farming is a technique to grow crops without using chemical pesticides, fertilizers, genetically modified organisms, antibiotics and growth hormones. The concept we know today as 'bio-organic farming' is a mixture of different designed biological formulations embedded mainly in the "organic agriculture speaking economies". The attentiveness of bio-organic farming in developing countries is rising because it requires less chemical inputs and places more faith on natural and human resource available. In India, this idea is revolutionized in early 21st century, particularly in era when knowledge of agriculture sciences improved along with incorporation of farming systems of the west. Success stories of Bio-organic farming on small land holdings, especially under rain fed zones; tribal areas and North West to North East Himalaya are promoting organic farming in India.

The Green Revolution technology acceptance "between" 1960 to 2000 has increased wide varieties of agricultural crop yield per hectare which increased 12-13% food supply in developing countries. According to recent study, a 10% point's increase in the use of high-yielding crop varieties in developing countries in the period 1960-2000 led to increases in GDP per capita of approximately 15% (Gollin Douglas, *et al.*, 2018). Southeast Asia and India were the first developing countries to show the impact of GR on varieties of rice yields (Biopesticides and Biofertilizers, 2000). Use of Biopesticides and Biofertilizers can play a major role in dealing with these challenges in a sustainable way (Suman Gupta., 2010). The global population will grow to 10.12 billion by 2100 (UN, 2010/ 2011). In order to fulfill the food demand of growing population; higher and advance productive agricultural materials are required (UN, 2010/ 2011). Globally more than 125 species of natural enemies are commercially available for biological control programs such as *Trichogramma* sp.,*Encarsia Formosa* str.*gahan*, and

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Phytoseiulus persimilisAthias-Henriot (Birch A.N.E., 2011).

The use of domestic bio-pesticides in the farming practices is old aged practices. It is highly eco-friendly and can obtain from nature directly. It is almost free of cost and there is no adverse impact on human health, soil, animals, plants and environment. Bio-pesticides are consequential from natural materials such as animals, plants, bacteria, and minerals. Bio-pesticides tend to be less toxic, more quickly biodegradable, and more targeted to the specific pest (US Environmental Protection Agency., 2008).

There are number of challenges faced by the agricultural sector at policy, commercial and infrastructural level. Some of the major problems and constraints for organic farming in India includes lack of awareness, output marketing problems, shortage of bio-mass, inadequate supporting infrastructure, high input costs, marketing problems of organic inputs, low yields etc. In order to address the aforesaid challenges in a better way, Jaivik Krishi (JK) package can be developed by using the combination of bio-formulations, which may help common Indian farmers in different parts of the country to produce sustainable organic agricultural crop.

Interest in organic agriculture methods is growing, especially in areas where the present farming system has degraded resources essential to agricultural production (especially land). Non-production factors, such as the farmer's health, are also mentioned as a reason for shifting to organic management. Consumers also have an interest in organic agriculture. Consumer awareness of the environmental costs of agriculture (such as the deteriorating quality of drinking water and soil, and the impact of agriculture on landscape and wildlife) is increasing. The awareness of environmental quality and health is often promoted by environmental groups, especially in developed countries. The resulting demand for organic products creates the opportunity to sell organic products at premium prices, enabling organic farmers to continue, and often expand.

Products from Cow (*Bos indicus*) particularly those with hump (Indigenous breed) is one of the key component in agriculture from ancient period, hence provision of utilizing products from at least “one cow per hectare” need to be promoted for Jaivik Krishi activities in organic farming. Suggestive evidence indicates that bio-organic food intake may reduce the risk of allergic disease and of overweight and obesity, but residual confounding is likely, as consumers of bio-organic food tend to have healthier lifestyles.

The cow’s urine (*Gau-mutra*) has been described as a liquid with innumerable therapeutic values, capable of curing several incurable diseases in human beings and plants. Cow urine is rich source of macro, micronutrients and has disinfectant and prophylactic properties. Indigenous cow milk possesses less cholesterol and high protein having high biological and nutritional value. It is easily digestible and extensively used in *Ayurvedic* medicines for treatment of various ailments. Milk from indigenous breed of cow is known to have better therapeutic values (R.K. Pathak and R. A. Ram, 2005).An important produce from Cow is *ghee* which acts as carrier agent for subtle energies. When cow ghee is burned with rice it produces oxygen, Etholine oxide, propylene oxide, and Formaldehyde, which brings immunity against bacteria, Propylene oxide induces rain. Another product, *cow dung cake* has been found to be rich in actinomycetes and was used as medicine in ancient cultures of India, South Asia, North and South America, Scandinavia and eastern and western parts of Europe (A.D.K. Dittrich and A.J. Helden, 2012).

Various BOFs have been produced by mixing cow products as described in earlier studies (K. V. Raghavendra *et,al.,* 2014). In general, cow products are mixed together in defined ratio and kept in mud pot for few days. This study is focused on the antimicrobial activities of dung extracts of Indian and imported cows against plant pathogens and their importance as plant growth promoting bio-organic formulations, using tomato as model crop. The increasing concern for environmental safety and global demand for pesticide residue free food has induced extreme interest in crop production using eco-friendly products which are easily biodegradable and do not leave any harmful toxic residues besides conserving nature. So it is necessary to use natural products like bio-organic formulation to produce chemical residue free food crops and hence bio-organic formulation can play a major role in organic farming.

MATERIALS AND METHODS

Organic Farming is a farming method which aims at cultivating the land and raising crops in such a way that the soil is kept alive and in good health by use of organic wastes (crop, animal and farm wastes, aquatic wastes) and other biological materials. It aims to produce crop with a high nutritional value.

A. Procurement of seed: The seed of tomato were obtained from Muzaffarnagar seed market (India). Tomato (*Solanum lycopersicum*) is one of the most important vegetable plants in the world. It originated in western South America, and domestication is thought to have occurred in Central America. Tomato has been widely used not only as food, but also as research material.

B. **Formulating BOFs:** Take water in a large container then added all types of leaves. Turn on the stove and keep a large vessel on it pouring all the cow urine in it. After ten minutes, put the mixture of blended leaves in the vessel and stir. Add water to

make the mixture of total 4 liters. Boil the mixture for one hour from now. After turning off the stove, let the mixture cool down. Now take a cotton cloth preferable of white color and filter down all the mixture from it. Store the solution in a drum. For a liquid foliar spray apply 3% to 10% in water, and for soil, use 100-200. It's used per acre during irrigation. Taking this formulation as Base solution, three BOFs are made as follows:

1. DPE (Dasha Parni Extract):'Dasparni' word comprises of two different words 'Dasha' means Ten and 'Parna' means leaf of plant or tree.This plant growth promoting formulation was made by mixing Base solution with leaf extract from 10 important medicinal plants as shown in Table 1.

2. ACAE (*Azadirachta Capsicum Alliums* Extract): ACAE, also a plant growth promoting BOF, is formulated by mixing Base solution with extracts of chilli, garlic and tobacco (Table 2).

3. LEAI (Leaf Extract of *Azadirachta indica):* This bio-pesticide BOF was formulated by adding Neem extract to the base solution to check activityof sucking pests and Mealy Bug. Its formulation is shown in table 3.

Table 1. Materials used preparation of DPE

Materials	**g/ l**	**Materials**	**g/ l**
Castor plant leaves	20gm	Hing	0.1gm
Neem tree leaves	20gm	Ginger	4.0gm
Guava tree leaves	20gm	Turmeric	4.0gm
Tulsa plant leaves	20gm	Tobacco	10gm
Indian Bail plant leaves	20gm	Chili	10gm
Mango tree leaves	20gm	Garlic	10gm
Pomegranate tree leaves	20gm	Cow urine	200ml
Hibiscus Rosa plant leaves	20gm	Cow dung	200gm
Mari gold plant leaves	20gm	Tap water	2litre
Yellow oleander leaves	20gm	-	-

Table 2. Materials used preparation of ACAE

Materials	**g/ l**
Cow urine	500 ml
Tobacco powder	12.5 gm
Green Chili	12.5 gm
Garlic	6.0gm
Neem leaves	100gm

Table 3. Materials used preparation of LEAI

Materials	**g/ l**
Water	2 liter
Cow urine	100 gm
Cow dung	20gm
Neem leaves	100 gm

C) Plant growth promotion using Bio-formulations (PGPB)

Preparation of Soil Mixture

To evaluate DPE, ACAE, LEAI application, a special soil mixture was prepared. The configuration of soil mixture contains of Coco-peat, loamy soil and cow dung (3:4:1), mixed well and filled in the experimental pots (75 × 38cm) and 12 experimental pots were arranged for treatments.

***In situ* experiments**

1. Preparation of Nursery pots

The seeds of tomato were sown in plastic pot filled with equal amount of designed soil mixture. After twenty days, seedlings were transplanted into experimental pots.

2. Transplantation

i) Research Trial

We established small experimental trial to check the effect of different concentration of bio-organic formulations. During transplantation, seedlings were treated with different concentrations of BOFs (45ml, 50ml and 55ml, respectively for each formulation) in replicates of three. At every six day interval (till data collection after 60 days of growth), same treatment of bio-organic formulation was repeated. For further experimentation, dosage with optimal growth parameters was chosen for each BOF.

ii) Optimal dosage experimentation

Tomato plantings were transplanted as a triplicate of nine pots containing soil mixture. Each set of nine pots were further divided into set of three and each set was treated with 45 ml DPE/set, 50 ml ACAE/set and 55 ml LEAI/set, respectively at the onset of vegetative phase. Irrigation was done by common agricultural practices throughout the experiment. At

every six day interval (till data collection after 60 days of growth), same treatment of bio-organic formulation was repeated.

3. Analysis of phenotypic characters

Plant growth was measured after 60 days taking into account phenotypic characters such as plant height (PH), plant weight (PW), shoot length (SL), shoot weight dry (SD) and fresh (SF), root length (RL), root weight dry (RD) and fresh (RF), number of leaves (NL), number of fruit (NF) and fruit weight (FW). These phenotypic characters were observed and recorded from 15^{th}-60^{th} day. After 60 days final measurement pf phenotypic characters was documented. Further, the dry weight was obtained after oven drying at 65^0C for 48 hours using two plant samples from each treated replicate.

RESULT

Firstly, dosage concentration of individual BOFs was optimized using research trial (Table 1). Strikingly, different dosage of DPE, ACAE and LEAI affected the growth attributes of trial crop used (tomato). Effect of optimal dosage concentration of each BOF is tabulated in Table 1. When compared with control, statistically significant increase in NL, SF, SD and RD was observed in case of plants treated with 45 ml DPE, 50 ml ACAE and 55 ml LEAI. The percent increase in total biomass of both fresh and dry plants was higher in BOFs treated case was found to be higher by 1.45%, 1.22% and 0.20%in aforesaid concentrations of DPE, LEAI and ACAE respectively,than control case. Similarly, the total dry biomass was found to be increased by 1.81 %, 1.49 % and 1.04 % respectively in DPE, ACAE and LEAI.

Table 1. Differential Effect of BOFs on Biomass of Tomato Plant.

Treatment groups	Fresh Biomass	Total SF & RF (gm)	% Increase in fresh biomass	Total SD& RD (gm)	% Increase in dry biomass
Control	160.45	150.2	0.00	21.74	0.00
DPE -45 ml	233.09	206.53	1.45	39.21	1.81
ACAE -50 ml	195.21	180.05	1.22	32.48	1.49
LEAI -55 ml	174.35	157.74	0.20	22.75	1.04

Overall, the growth was found to be higher in treated cases as compared to control. Plants treated with DPE, ACAE and LEAI showed significant difference in shoot length, leaf count, root length and weight of the tomato plants (Fig. 2). All phenotypic attributes responded positively on application of various BOFs. Tomato growth parameters such as plant height (PH), plant weight (PW), shoot length (SL), shoot weight dry (SD) and fresh (SF), root length (RL), root weight dry (RD) and fresh (RF), number of leaves (NL), number of fruit (NF) and fruit weight (FW) were significantly increased under the influence of DPA, ACAE and LEAI application (Fig-1). Data is summarized in Table 2. It is evident from Table 2, fig. 1 and fig. 2 that application of DPE has the maximum effect on overall growth, followed by ACAE and then LEAI.

Table 2. Effect of various dosage of bio-organic formulation on Biomass of Tomato.

SET	NL	NF	FW (gm)	SF (gm)	RF (gm)	SD (gm)	RD (gm)	RL (cm)	SL (cm)	PH (cm)
Control	102.38	05	10	090.26	62.41	11.23	06.07	102.24	41.61	24.57
DPE (45ml)	165.61	15	91	152.11	59.67	23.26	11.45	122.40	56.61	43.00
ACAE (50ml)	145.25	11	65	132.60	44.58	20.67	05.76	76.00	47.00	35.00
LEAI (55ml)	160.92	20	83	102.53	52.07	14.43	04.58	134.34	46.23	50.00

The following values are tabulated by taking mean of replicates on optimal BOF concentration i.e. DPE (45ml), ACAE (50ml) and LEAI (55ml). Abbreviated words are as plant height (PH), plant weight (PW), shoot length (SL), shoot weight dry (SD) and fresh (SF), root length (RL), root weight dry (RD) and fresh (RF), number of leaves (NL), number of fruit (NF) and fruit weight (FW).

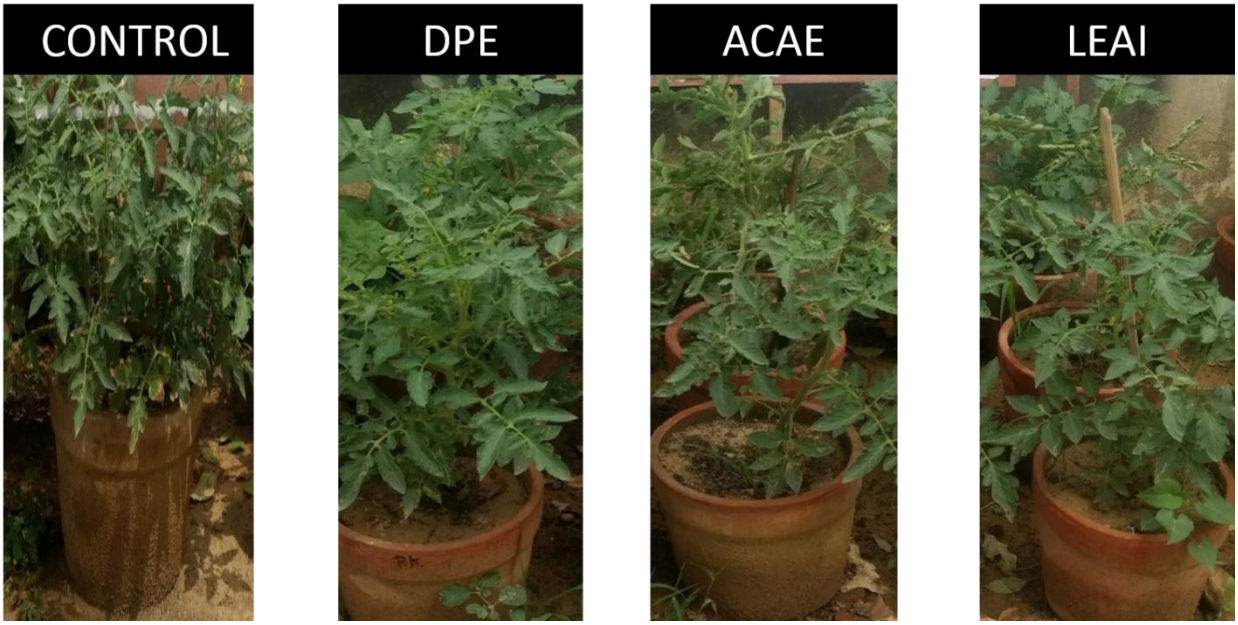

Fig 1. Effect of various dosage of bio-organic formulation on Biomass of Tomato.

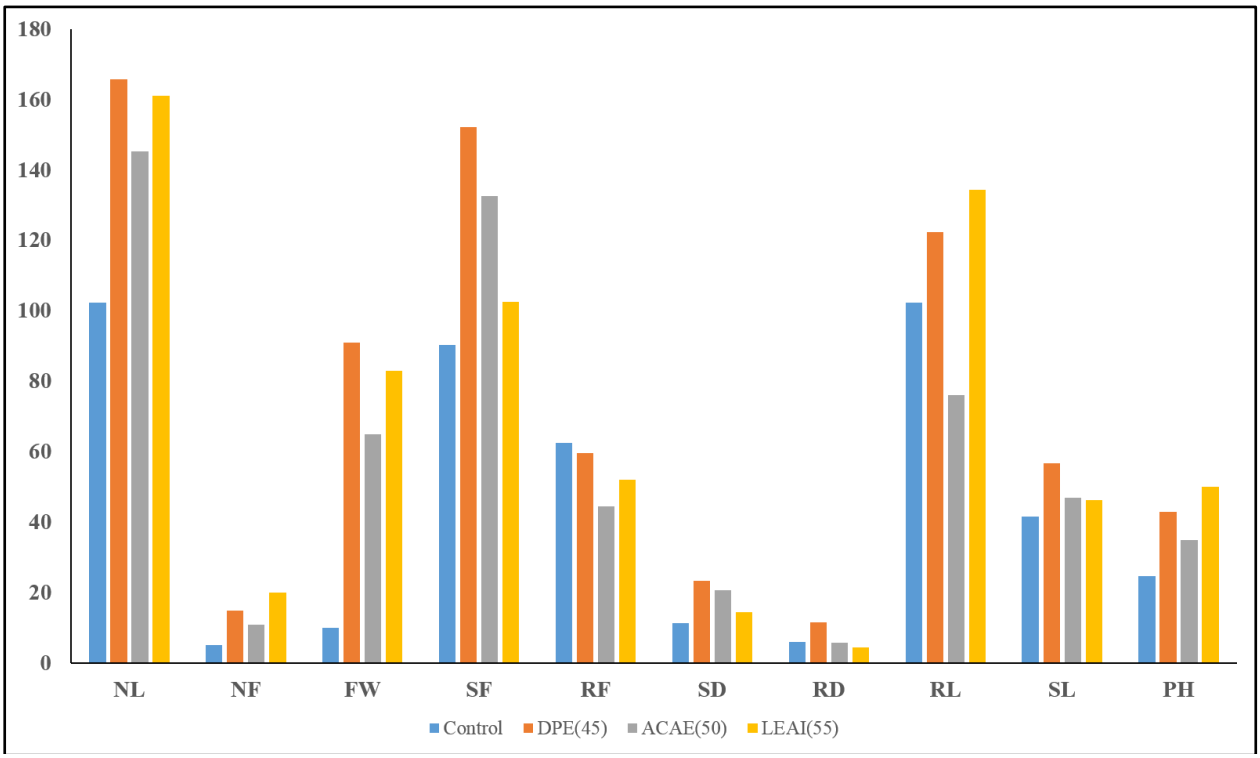

Fig 2. Reproductive growth in Tomato (control vs Treated) after 60 days of sowing.

Further, to depict the accuracy and significance of data, observations were statistically tested using independent t-test on mean values of different phenotypic characters.

Table 3. Independent t-test on various dosages of BOFs on Biomass of Tomato to calculate the significance level of observations.

Biomass Parameter	Control	DPE DOSE 45ml/plant		ACAE DOSE 50 ml/plant		LEAI DOSE 55 ml/ plant	
	Mean	Mean	p-value	Mean	p-value	Mean	p-value
NL	102.3	165.6	0.00**	145.2	0.03*	160.9	0.007*
NF	5.00	15.00	0.005*	11.00	0.00*	20.00	0.187
FW(gm)	10.00	91.00	0.001**	65.00	0.023*	83.00	0.263
SF(gm)	90.260	152.11	0.002**	132.605	0.072	102.532	0.288

RF(gm)	62.41	59.67	0.001**	44.58	0.787	52.07	0.332
SD(gm)	11.23	23.26	0.003**	20.67	0.050*	14.43	0.320
RD(gm)	6.07	11.45	0.002**	5.76	0.398	4.58	0.356
RL(cm)	102.24	122.4	0.113	76.00	0.127	134.34	0.576
SL(cm)	41.61	56.61	0.032*	47.00	0.697	46.23	0.521
PL(cm)	24.57	43.00	0.044*	35.00	0.648	50.00	0.325

Test applied: Independent t test (Testing of means),*Statistically Significant at 5% level of Significance ($p<0.05$) **Highly Significant at 5% level of Significance ($p<0.005$).

DISCUSSION

Due to the reported potential performance of BOFs on several crops and, DPE, ACAE and LEAI in *Solanum lycopersicum* plant, the present study was carried out in an attempt to elucidate its effect on vegetative and reproductive growth of pot cultured tomato plant. BOFs showed significant and consistent improvement in vegetative growth and also significantly increased the number of fruits and number of leaves at different intervals throughout the period of experiments as compared to the control indicating its potent growth stimulating activity. These evidences tempt us to speculate that apart from the aforementioned probable DPE action, the other possible mechanism i.e. development of disease resistant in tomato might be contributed to free microbial metabolites of BOFs solution.

The result is in accordance with the previous results conducted with BOFs and extract of leaves further suggesting that the available form of active principles in BOFs and higher arriving water in plant system (45 ml / plant) might be contributing in the regulation of plant growth. Taken together, it can be summarized as BOFs might possess both vegetative and reproductive stimulation mechanisms in it actions and such apparent dual action of BOFs would be more advantageous to the other existing commercial organic inputs.

It is well recognized that the foliar application of fresh Drumstick leaf and twigs juice along with *Panchagavya*, Humic acid, and de oiled seed cake can positively influence the plant biomass parameters (Prabhu, 2010; Balakumbahan and Rajamani, 2010; Emmanuel 2011a & b). It has been reported that 30 times diluted *Moringa* leaf extract significantly increased seed and seedling vigour in wheat (Afzal *et al.,* 2008), Maize (Basra *et al.,* 2011) and many grass species including *Cenchrus ciliaris, Panicum antidotala* and *Echinochola crusgalli* (Nouman *et al.,* 2012a). Moringa leaf extract spray increased the yield in crops like peanut (5319 kg/hec), onion (4194 kg /hec) and black bean (1194 kg / hec) compared to their respective control (Foidl *et al.,* 2001).

Several experiments were sustained that the increased growth and yield parameters by foliar application of *Moringa* leaf extracts at different percentage and combined with *Panchagavya* and Humic acid. The mixture of all different organic substances are economically viable for producing higher dry herbage yield in sacred basil - *Ocimum sanctum* L., (Prabhu *et al.,* 2010). The same impacts of higher value of growth and yield were recorded in Senna crop *Cassia* a*ngustifolia* var.KKM.1 (Balakumbahan and Rajamani, 2010).

The field investigation established the fact that application of *M. oleifera* de-oils seed cake without pre-decomposition as an organic fertilizer on a maize farm achieved significant improvement on soil nutrient as well as the plant yield, as compared to the control (Emmanuel *et al.,* 2011a & b). *Moringa* leaf extract (MLE) is a plant growth enhancer that improves seedling emergence of rangeland grasses, seedling vigor and growth as compared to other seed priming techniques (Nouman *et al.,* 2012 a & b). Wheat (*Triticum aestivum*) seeds priming with *Moringa oleifera* leaf extract had induced the antioxidative system together with increased chlorophyll contents, ascorbic acid and soluble phenolics contents (Yesmeen *et al.,* 2013).

Remaining to the reported potential performance of *Jeevamrit* on tomato plants (Rajamani *et al.,* 2014), the present study was carried out in an attempt to explain its effect on vegetative and reproductive growth of pot cultured tomato plant. The composition of dasparni extract was first developed and applied on tomato and papaya at AL Khaly farm in UAE to withstand temperature and well crop was observed (Vijayan Pillai, 2012). It has been reported that 30 times diluted Sahjanleaf extract significantly increased seed and seedling vigour in wheat (Afzal *et al.,* 2008), Maize (Basra *et al.,* 2011) and many grass species including *Cenchrus ciliaris, Panicum antidotala* and *Echinochola crusgalli* (Nouman *et al.,* 2012a). Sahjan leaf extract spray increased the yield in crops like peanut (5319 kg/hec), onion (4194 kg /hec) and black bean (1194 kg / hec) compared to their respective control (Foidl *et al.,* 2001).

Several experiments were sustained that the increased growth and yield parameters by related to leaves application of Sahjanleaf extracts at different percentage and combined with*Jeevamrit*. The mixtures of all different organic substances are economically viable for producing higher dry herbage yield in sacred basil (Prabhu *et al.,* 2010). The same impacts of higher value of growth and yield were recorded in Senna crop *Cassia* a*ngustifolia* var.KKM.1 (Balakumbahan and Rajamani, 2010). The field investigation established the fact that application of *M. oleifera* de-oils seed cake without pre-decomposition as an organic fertilizer on a maize farm achieved significant

improvement on soil nutrient as well as the plant yield, as compared to the control (Emmanuel *et al.,* 2011a & b). *Moringa* leaf extract (MLE) is a plant growth enhancer that improves seedling emergence of rangeland grasses, seedling vigor and growth as compared to other seed priming techniques (Nouman *et al.,* 2012 a & b).

Triticum aestivum seeds priming with Sahjan leaf extract had induced the antioxidative system together with increased chlorophyll contents, ascorbic acid and soluble phenolics contents (Yesmeen *et al.,* 2013). The leafy spray of aqueous extracts of 2% of leaf and 3% of twig of *Moringa oleifera* on Rocket plants (*Eruca vesicaria*) potentially increased all measured growth criteria of Biomass and physiological activities like photosynthetic rates, stomatal conductance, the Bio-molecules of chlorophyll a and b, carotenoids, total sugar, total protein, phenols, ascorbic acid, N, P, K, Ca, Mg, Fe as well as growth promoting hormones-Auxins, gibberellins and cytokinins. The extracts at all concentrations applied, negatively reduced the level of lipid peroxidation and the activities of antioxidant enzymes (Catalase, proxidase, superoxide, dismutase). Thus it is concluded that Sahjanleaf and twig extracts can be used as bio-organic fertilizer for various crops due to its high productivity, high nutritive value, antioxidant effect, and easy preparation, low cost and environmental friendly nature. (Mona M. Abdalla, 2013).

In our previous study we showed the empirical evidence that the treatment of bio-organic formulations caused significant as well as moderate improvement on biomass level of *Brassica olerarcea* .L, (Rajamani *et al.,* 2014) further sustaining its potential in tomato. Since DFLJ effectively improves the root surface area, it causes early flowering in tomato. The significant growth perhaps might include the establishment of favorable microclimate niche around the rhizosphere for consortium and *Jeevamrit* microbial community to enhance feeding root growth.

These confirmations attract us to risk that apart from the above-mentioned probable bio-organic formulations action, the other possible mechanism i.e. development of disease resistant in tomato might be contributed to free microbial metabolites of *Jeevamrit* solution and beneficial inoculum of consortium.

CONCLUSION

From the above enumeration, it can be concluded that bio enhancers could be a potent source to improve soil fertility, crop productivity and quality. This can also be a potential alternative for fertigation which is becoming common in most of the crops. However, care should be taken that bio enhancers which are used in limited quantities cannot meet the entire nutrient requirement of the crops. These simply catalyze quick decomposition of organic wastes in to humus, hence incorporation of enough bio mass preferably combination of monocot and legumes duly supplemented with animal wastes will be helpful in quality production of humus, which is prerequisite for improving soil fertility and crop productivity. Combined with manures and frequent use of bio enhancers can address many challenges of agriculture and will be surface way for sustainable agriculture through organic resources. It acts as manure for soil and plants. ACAE was best pest control comparison to other chemical pest control. LEAI to control sucking pests and Mealy Bug. This process was strongly dependent on the environmental condition.

Bio-organic formulation ACAE is increasing level from other formulation DPE, LEAI. Mean number of leaves is better in high concentration of DPE (165.6) other formulations ACAE, and LEAI. Number of fruits output is better for ACAE (20) than other formulations DPE and LEAI. Fruits weight is also increasing by applying DPE (91) other formulations ACAE and LEAI. Fresh shoot weight is also increasing by applying DPE (152.115) other formulations ACAE and LEAI. Dry shoot weight is output better for DPE (23.2657) than other formulations ACAE and LEAI. Shoot length is also better for DPE (56.61) other formulations of ACAE and LEAI Plant height is better for ACAE (50.00) other formulations ACAE and LEAI.

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RESEARCH ARTICLE

PHYSIOLOGICAL PLASTICITY OF 60 CULTIVARS OF *ARACHIS HYPOGAEA* UNDER NATURAL DROUGHT CONDITIONS OF SEMIARID REGION IN INDIA

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Abstract: Physiological plasticity of sixty peanut cultivars, belonging to four botanical groups, were evaluated during *Kharif* season under well-watered (with protective irrigation; P) and natural drought(under rain-fed;RF) conditions and compared for physiological and yield attributes to identifythe promising ones. The days required for 50% flowering varied from 24.5-34.0 days and 26.0-37.7 days with an average of28 and 30 days in P and RF crops, respectively. The natural drought under RF condition delayed crop maturity (112-132 days) as against 113-119 maturity days in P.Interestingly, 30 cultivars matured within 113 days at 2130 ºC degree days under both the condition indicating their adaptability and plasticity to drought. Though themean pod yield of peanut cultivars were 1260 kg ha^{-1}under P and 1130 kg ha^{-1}under RF conditions, cultivars ICGS 5, JGN 23, AK 265, GG 5, GG 11, GG 16, Girnar 1, AK 159, SBXIshowed > 1300 kg ha^{-1} pod yield under both the conditions. The cultivars with early flowering, high SCMR,low SLA, high yield and HI,and early maturity showed the escape mechanism and were considered as most promising for rain-fed cultivation, where there is greater likelihood of drought situation.Our study showed, Spanish bunch (VUL) group was more suitable compared to Virginia bunch (HYP), Virginia runner (HIR) and Valencia (FST) peanut group for desirable traits in rain-fed condition. The cultivars JGN 23, SB XI, and Girnar1 showed most of the desirable characters with high physiological plasticity and hence, can be of immense use for rain-fed conditions.

Keywords: Degree days,Flower initiation, Natural drought, Peanut, Physiological Plasticity

INTRODUCTION

The peanut is a major food legume of tropical and sub-tropical region of the globe and grown in about 110 countries under rain-fed condition mostlywith full of uncertainty of weather conditions (FAO, 2014, Singh *et al*., 2013). The productivity of peanut is less than 1000 kg ha^{-1} in more than 30 % of the peanut growing countries in the world, whereas it is between 1000-2000 kg ha^{-1} in 40-45 % of the countries.Only 25% of the 110 countries possess productivity above 2000 kg ha^{-1} (FAO, 2014). India though has the largest peanut area (5.53 m ha) in the world, but its average productivity is only around 1300 kg ha^{-1}, whichfluctuates between 990 to 1750 kg ha^{-1} mainly due to its cultivation as rain-fed crop without protective irrigation during *kharif* season (Singh 2004, 2011; Singh *et al*., 2013).However with good cultural practices and protective irrigations farmers are harvesting up to 4000 kg ha^{-1}pod yield in certain areas (Singh, 2011). This calls for the attention of researchers to look into the matter and modify the recommendations.

Crop productivity per unit water is important especially for developing water use efficient cultivars(Codon *et al*.,2004). Physiological parameters associated with drought tolerance can be utilized foridentification of drought resistant cultivars which can be used in crop improvement programmes (Nautiyal *et al*., 1999, 2012; Singh *et al*., 2013, 2014a, b). The leaf area and specific leaf area (SLA) are strongly correlated with photosynthesis and transpiration efficiency and thus dehydration tolerance capacity(Nageswara Rao *et al*., 1992; Wright *et al*., 1994). Chlorophyllisthe major photosynthetic pigment and high chlorophyll density under water deficit stress is an indicator of tolerance (Arunyanark *et al*., 2008). The SLA and SPADchlorophyll meter readings (SCMR) are quite useful, among the surrogate non-destructive traits as indirect selection tools for drought tolerance (Upadhyay, 2005; Nigam, 2008).

As majority of the peanut growing area belongs to semi-arid environment, information is required in making strategies for improvement of drought tolerant cultivars with high yield. In India, now there are more than 190 released peanut cultivars, but there are 50-60 cultivars at the most in seed chain. There is hardly any consolidated report of testing all of these cultivars for drought tolerance under rain-fed condition together.Plant's response to drought are always dynamic in nature with respect to space, time, intensity of stress etc. Change in an organism's phenotype triggered by such variationsis called phenotypic plasticity (Bradshaw, 1965).Many researchers have tried to assess the plasticity of

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different plant species under challenging environments and found that this inverse relationshipbetween tolerance and plasticity was fit for fitness-related traits but was trait-dependent for underlying traits (Couso and Fernandez, 2012).We tried to measure the plasticity of these genotypes through analysing the performance of 60 peanut cultivars during *kharif*season under both protected and natural drought (rain-fed) condition to find out the physiological parameters responsible for high yield and identification of cultivars with drought escape mechanism.

MATERIALS AND METHODS

Field experiment

A field experiment was conducted at the research farm of ICAR-Directorate of Groundnut Research, Junagadh, India, in a clayey calcareous vertisol soil having medium fertility in semi arid region of south Saurashtra. Sixty released peanut cultivars belonging to four different botanical groups (Table 1), comprising of 34 Spanish bunch (VUL), 16 Virginia bunch (HYP), 9 Virginia runners (HIR) and one Valencia (FST) were sown during *Kharif* season-2012 in a single row plot in screening blocks. The field was prepared and 40 kg N, 50 kg P and 50 kg K was applied in the soil as basal dose (Singh and Basu, 2005). All cultivars were sown in a 5 m row and having 45 x 10 cm spacing in three replications inJuly, 2012 under sufficient moisture conditions. In the control plots (P) protected irrigationwas provided whenever there was short fall in rain during the entire cropping season.On the other hand, in rain-fed plot (RF) crop was raised under natural condition without any irrigation. The crop was harvested at physiological maturity of respective botanical groups.

Drought spell and its intensities during cropping season

In the present study, the cropping season spanned between 28^{th} and 47^{th} standard meteorological weeks in year 2012 during which the mean maximum and minimum temperature were 33.2 $^{\circ}$C and 24.7°C, respectively, while mean relative humidity was 72.1% and total bright sun shine hours was 594 (Table 2). The total rainfall from sowing till harvest was only 229mm as against the total evaporation rate of 594 mm and there were, a total of three drought spells of various intensities observed during the entire cropping season in rain-fed crop. The crop faced the first drought spell of 10 days during 11 to 20 DAS with only 1.2% rainfall against the evaporative demandof 34.9 mm, the second drought spell of 20 days during 21 to 40 DAS with 13% rainfall against the evaporative demandof 58.5 mm and the last drought spell of 40 to 60 day starting from 72 DAS to harvest where the crop has received only 2.0 mm rainfall which was 0.6% of evaporative demand.

Flowering and morphological parameters

The days to flower initiation, 50% flowering, and total flowers produced during first 10 days were recorded in each cultivar under both the conditions. At 70 DAS three plants from each cultivars and treatments were uprooted and plant height, number of leaves on main axis, number of pods and pegs,and dry biomass per plant was recorded. Keeping the base temperature uniformly at10ºC, the cumulative thermal time (CTT) expressed as θ (ºC d, number of degree-days above the base temperature) required for initiation of flowering (θ_{If}), 50% flowering (θ_{f50}) and maturity (θ_m) were calculated by summation of daily mean temp minus 10 (Vasudeva et al 1992).

SCMR, Leaf Area, Specific leaf area (SLA) and yield parameters

The SCMRwere recorded in the third fully expanded leaf facing sun from the top of the peanut plant at 70 DAS using SPAD-502 (Konika-Minolta,Japan)in each cultivar in triplicates. Twenty leaflets from third compound leaves were collected for measurement of leaf area, specific leaf area (SLA) and relative water content (RWC). Crop was harvested at maturity, dried in sun for a week and pod and haulm yields, HI and other post-harvest observation was recorded.

Statistical analysis

All the data were subjected to statistical analysis following Gomez and Gomez (1984). Linear correlation was worked out between various physiological parameters studied under protected and rain-fed conditions. One-way ANOVA was also carried out for both the treatments using DSTAAT software.

RESULTS

The drought caused initial plant death, delayed flowering and reduced leaf area, SLA, plant height, number of flowers and harvest index, but increased SCMR under rain-fed condition. Significant variation among cultivars was observed for various physiological parameters the details of which are discussed below.

Flowering

In peanut cultivars, the initiation of flowering started from19 to 28 DAS under protected condition with an average at 23 DAS, but under RF the average flower initiation time was 26 DAS i.e. delayed by 3 days (Table3). Accordingly, the 50% flowering time was attained in 28 DAS under P and 31 DAS in RF conditions which, corresponded to cumulative thermal time θ_f of 546 and 602 ºC d, respectively. Thus mean 50% flowering was also delayed by 3-4 days in RF condition.We found, 20 cultivars flowered within 26 days at θ_f of 506 ºC d under P conditions,whereas 21cultivars flowered within 30 days at θ_f of 565 ºC d in RF condition. Interestingly 14 cultivars were common under both the situations. The numbers of flowers produced from the day of 50% flowering to next 10 days showed very high

variation among cultivars.It ranged from 19 (TPG 41) to 111 (HNG 69) flowers per plant under P and 10 (JAL 286) to 105 (BAU 13) under RF.

RWC, SCMR and SLA

The RWC, SCMR and SLAmeasured at 70 DAS showed significant variation within the cultivar as well as under different treatment conditions (Table 3). The mean RWC value of these cultivars was 95.6 (with a range of 92.3 to 97.1) under P conditions which decreased to 84.9 (with a range of 71.5 to 91.8) under RF condition. Interestingly, there were 35 cultivars showing >85 RWC under RF conditions. The mean SCMR value of these cultivars was 37.5 under P conditions which increased to 39.5 under RF. Seventeen cultivars under P and 24 cultivars in RF showed higher SCMR values of >40 and of these 10 cultivars were common under both the conditions (Table 5). The mean SLA was 185 and 147 cm^2g^{-1}under P and RF conditions, respectively. Among the cultivars highestSLA was observed in VRI 2 (293 cm^2g^{-1}) and lowest in ICGS 37 (135 cm^2g^{-1}) in P, however under RF the SLA was highest in Chico (210 cm^2g^{-1}) and lowest in Kadiri 9(112 cm^2g^{-1}). Twelve cultivars under P showed SLA values less than 160 cm^2g^{-1},while 24 cultivars showed SLA values less than 140 cm^2g^{-1}under RF condition indicating drought adaptive response in these cultivars (Table 5).

Plant height, number of leaves and pods

The morphological characters varied significantly with the treatment conditions (Table 4). Under protected condition mean plant height was 43.6 cm, which decreased to 39.8 cm under rain-fed condition.Similarly, theleaves on main axis was reduced from 16 to 14 under RF conditions (Table 3). Under protected condition the number of cultivars with a greater number of leaves on main axis was higher but, under RF there were equal no. of cultivars showing less and more leaves. On an average the cultivars GG 2, JGN 23, LNG 2, GG 7, GG 14, DRG 12 and TG 51 showed more leaves.

On an average there was 11.6 pods $plant^{-1}$in P and 14 in RF at 70 DAS and out of 60 cultivars, nine showed more number of pods under P condition and only seven under RF condition. The cultivars TPG 41, Gangapuri, DRG 14 and TLG 45 produced more number of pods. Five cultivars which showed more pods under P did not maintain same trend under RF. Interestingly, three cultivars SB IX, JGN 23 and Pratap Mungfali1 showed better response with more number of pods under RF.

Maturity period and observations at harvest

There was a considerable effect of drought on the overall maturity of the crop as a result the cultivars under RF condition took 112-132 days with a CTT of 2114-2420 ºC d to mature as against 113-119 days with 2130-2224 ºC d in protected condition. Interestingly, 33 cultivars matured within 112 days at 2114 ºC d under RF condition and 30 cultivars matured within 113 days at 2130 ºC d under P condition and more so 30 cultivars were common in both the condition indicating their adaptability and plasticity to drought.

There were significant differences in the mean pod yield of peanut under protected (1260 kg ha^{-1}) and RF (1130 kg ha^{-1}) conditions. Seventeen cultivars showed > 1450 kg ha^{-1} pod yield under P, however 16 cultivars showed > 1300 kg ha^{-1} pod yield under RF condition and of these nine were common in both the conditions (Table 5). Due to continuous drought there was death in plant under RF conditions, but no death under protected condition. As a result, the average number of pods $plant^{-1}$increased under RF condition due to thinning of plant population and it was 11.4 under P and 13.2 pods $plant^{-1}$in RF condition.There was drastic reduction in the haulm yield of peanut under RF (2860 kg ha^{-1}) as compared to the one under protected (3330 kg ha^{-1}) conditions. Fifteen cultivars showed >4000 kg ha^{-1}haulm yield under P, however under RF condition only 12 cultivars could produce> 3300 kg ha^{-1}haulm yield.

DISCUSSION

In the present agriculture, for efficient use of water our focus should be to raise water use efficient cultivars both under irrigated as well as rain-fed conditions (Codon *et al* 2004). Though traits conferring capacity of dehydration avoidance and tolerance are available, integrated traits expressing tolerance at organ level are more useful (Singh 2011, Singh et.al.2013). Selection based on genetics, yield and physiology is part of physiological genetic approach (Reddy *et al*., 2003, Singh et al 2010). Flowering in peanut starts at 20 DAS with effective flowering observed at 30 DAS (Singh 2011). But there is diversity in maturing pods due to extended flowering period and pod yield depends upon flower production (Singh,2004, 2011). In this study, significant variation among cultivars was found for most of the studied traits. Under rain-fed condition, there was delay inflowering due to inenough rainfallduring 11-19 DAS however; during 20-31 DAS there was scanty rainfall (~10 mm), which initiated flowering with production of a greater number of flowers $plant^{-1}day^{-1}$ on anaverage.In present study, though 50% flowering was observed at 25-34 DAS under protected (P) and 26-38 DAS under rain-fed (RF) condition, but the effective flowering was observed between 28-38 DAS under P and 31-40 DAS under RF. We identified this as the critical yield determining stage which should not face drought.

Screening based on various physiological and agronomical traits resulted in identification of cultivars possessing desirable traits. In general, the early flowering, high SCMR, pod yield and HI, and low SLA were identified as the desirable traits under both the conditions. The cultivars showing early flowering, high pod yield and high HI, high yield and

SCMR, highSCMR and low SLA and high pod yield and early maturity in both the treatments are listed in Table 6. Further, the cultivars with early flowering, high SCMR,low SLA, and high yield and HI showed the escape mechanism and were considered as highly suitable for rain-fed cultivation under drought situation however, the one showing *vice versa* physiological traits were mostsusceptible.Though several cultivars having desirable traits under both protected and rain-fed conditions were listed in Table 5, the cultivars JGN 23, SB XI, andGirnar 1 showed most of the desirable characters and hence can be of immense use as donor parents for rain-fed conditions.

Reduced SLA provides lesser surface area for harvesting photosynthetic light, a protective mechanism of the photosynthetic pigments under stress condition as plants are not able to utilize all the absorbed photons and the unutilized photons is diverted towards the non-photochemical quenching through heat generation. Also the reduced SLA provide a lesser leaf surface area in direct contact with the ambient air circulation which causes a loss of water from leaves. Wunna*et al* (2009) reported positive association between SLA and HI in drought condition.

In this study, we found SCMR as a highly useful trait in identification of cultivars for drought tolerance. Bootang et al. (2010) reportedthat physiological parameters SCMR and SLW gave higher contribution to biomass under drought than pod yield and the HI and number of mature pods contributed to high pod yield. However, in this study, we found SLA and HI were highly useful traits for identifying cultivars under natural drought events.

Here in this study, the rain-fed crop faced three distinctly different drought spells from 11-20 DAS, 21-40 DAS and 68 DAS to harvest which resulted in delayed flowering, and lesser flowers production in first 10 days and affected yield and yield attributes. Seventeen cultivars showed > 1450 kg ha^{-1} pod yield under P, however 16 cultivars showed > 1300 kg ha^{-1} pod yield under RF condition and of these nine cultivars were common in both the conditions indicating their plasticity to drought stress. Earlier Nautiyal, et al. (2002) reported early stage drought in peanut does not affect yield, biomass productionand nodule dry weight.On the contrary, end season drought, in various peanutcultivars,increased SCMR and SLW,but reduced biomass, pod yield and seed size without affectingthe HI and number of (Bootanget al., 2010).The mean HI in this study under both facing and RF treatment was similar.However, imposition of drought under rain-fed condition increasedSCMR, but decreased RWC, number of flowers and pods and yield. Recently,SCMR has been found a more pertinent trait than SLA in summer peanut under transient water deficit stress condition (Kalariya et al. 2015a).

Table 1. List of selected 60 peanut cultivars used in this study

S.N.	Cultivars	Habit group	Year of release	Area of adoption	Special characters
1	AK-159	VUL	2002	Maharashtra and Madhya pradesh (MP)	High oil content
2	Chico	VUL	--	--	Early maturity
3	DRG 12	VUL	1994	Andhra Pradesh(AP), Tamil Nadu(TN), Maharashtra,Karnataka	High yielding
4	DRG 1	VUL	--	--	--
5	GG 2	VUL	1983	Gujarat	Water use efficient
6	GG 20	HYB	1992	Gujarat	Large seeded with low aflatoxin contamination
7	GG 5	VUL	1999	Gujarat	Drought tolerant; leaflets stay green at maturity
8	GG 6	VUL	2003	Gujarat	Early maturity
9	GG 4	VUL	1993	Gujarat	High yielding and early maturity
10	GG 7	VUL	2001	Gujarat & southern Rajasthan	Early maturity
11	GG 8	VUL	2006	Northern Maharashtra and Madhya Pradesh	---
12	Girnar 1	VUL	1988	Western Maharashtra, T.N. and A.P.	Multiple diseasesresistant,early maturity
13	Girnar 3	VUL	2010	West Bengal (WB), Orissa, Manipur	---
14	GPBD 4	VUL	2004	Maharashtra, Karnataka, AP & TN	---
15	ICGS 37	VUL	1990	Gujarat, northern Maharashtra and MP	Tolerant to end-of-season drought; photo-period insensitive
16	ICGS44	VUL	1988	Gujarat, northern Maharashtra & MP	High seed protein (25%) content
17	ICGV 86590	VUL	1991	Peninsular India	Multiple diseases resistant
18	ICGV 91114	VUL	2007	AP	Early maturity
19	JAL 42	VUL	--	--	Early maturity
20	JGN 23	VUL	2009	Madhya Pradesh	Drought tolerant
21	JL 24	VUL	1978	Maharashtra	Early maturity

22	JL 286	VUL	2004	Maharashtra	Early maturity
23	Kadiri5	VUL	2005	AP	Drought tolerant
24	Kadiri9	VUL	2009	AP	Tolerant to early and late season drought
25	PratapMungfali1	VUL	2005	Rajasthan	Early
26	SB XI	VUL	1965	Maharashtra	Tolerant to *Aspergilusflavus* colonization
27	SG 99	VUL	2004	Punjab	---
28	TAG 24	VUL	1991	Maharashtra	Early maturity
29	TG 37A	VUL	2004	Gujarat, Rajasthan, Uttar Pradesh (UP), Orissa, W.B. Bihar and Assam	Possesses fresh seed dormancy (up to 15 days)
30	TG 51	VUL	2008	W.B., Orissa, Jharkhand and Assam	---
31	TLG 45	VUL	2004	Maharashtra	Large seeded
32	TMV 2	VUL	1940	Tamil Nadu, A.P. and Karnataka	Widely adapted
33	TPG-41	VUL	2004	All India	Large seeds, high O/L ratio, 25 day fresh seed dormancy
34	VRI 2	VUL	1989	Tamil Nadu	Tolerant to ELS, LLS & rust
35	CSMG 84-1	HYR	1992	Uttar Pradesh Rajasthan and Haryana	Variegated kernel colour
36	CSMG 9510	HYR	2005	U.P., Punjab, & northern Rajasthan	40-45 day fresh seed dormancy
37	DSG 1	HYR	1997	Karnataka	--
38	GG 11	HYR	1984	Gujarat	Resistant to rust
39	GG 16	HYR	2006	TN, AP, Kerala & southern Maharashtra	---
40	ICGV 88448*	HYR	--	--	Extra bold
41	M 13	HYR	1972	Punjab	Tolerant to leaf spots
42	M 335	HYR	1986	Punjab	Large seeded,Tolerant to ELS and LLS,
43	Somnath	HYR	1990	Gujarat and Rajasthan	Large seeded, early maturity,
44	AK 265	HYB	2007	Southern Maharashtra, Karnataka,AP, and TN	Drought tolerant
45	B 95	HYB	1993	Southern Maharashtra.	Large seeded, high yielding
46	BAU 13	HYB	1993	Bihar	Large seeded
47	CSMG 884	HYB	1999	UP, Punjab and Rajasthan	Large seeded, early maturity
48	DRG 17	HYB	1994	Rajasthan, Punjab, UP & Haryana	Tolerant to moisture stress
49	GG 14	HYB	2003	Northern Rajasthan, Punjab, Haryana & UP	
50	Girnar 2	HYB	2008	UP, Punjab, northern Rajasthan	Large seeded, stay green leaves at harvest
51	HNG 10	HYB	1998	Uttar Pradesh, Punjab, Rajasthan and Haryana	High yielding
52	HNG 69	HYB	2010	UP, Punjab and northern Rajasthan	High yielding
53	ICGS 5	HYB	1992	UP Rajasthan and Haryana	Drought tolerant
54	ICGS 76	HYB	1989	Southern Maharashtra and Karnataka	Resistant to ELS and LLS
55	ICGV 86031	HYB	--	--	Tolerant of iron chlorosis
56	ICGV 86325	HYB	1994	Southern Maharashtra,AP,Karnataka,Kerala, TN	High yielding
57	Kadiri 3	HYB	1978	AP	Clustered bearing
58	LGN 2	HYB	2001	Gujarat & southern Rajasthan	High yielding
59	TKG 19A	VUL	1995	Konkan region of Maharashtra	Bold and HPS grade kernels
60	Gangapuri	FST	1971	Madhya Pradesh	Moderately resistant to foliar disease

***** The cultivars marked with are promising genotypes

Table 2. Weather parameters at various peanut crop growth stages at Junagadh, Gujarat India during the cropping season *Kharif* 2012

		Temperature (^{0}C)							
Growth Period	Crop growth stages	Max	Min	mean	RH(%)	BSS (h)	Evap (mm)	Rainfall (mm)	SMC at the end of the period
1-10 DAS (11-20 July)	Cracking, establishment and early vegetative growth	33.1	25.9	29.5	76.4	5.8	34.9	24.3 (69.6)	9.6%
11-20 DAS (21-30 July)	Vegetative growth	33.8	26.6	30.2	71.4	0.6	58.5	0.7 (1.2)	8.5%
21-40 DAS (31 July to 19 Aug)	Vegetative growth, flower initiation and peg initiation	32.7	25.8	29.2	76.5	1.8	76.3	9.9 (13.0)	7.5%
41 TO 67 DAS (20 Aug to16 Sept)	Flowering, Peg initiation to beginning seed	31.1	24.7	27.9	85.5	21.1	62.2	262.4 (422)	7.5%

68 TO 133 DAS (17 Sept to 20 Nov)	Beginning seed to full maturity and harvest	35.4	20.4	27.9	50.7	565.2	361.6	2.0 (0.6)	6.5%
Mean		33.2	24.7	28.9	72.1				
Total						595	594	299 (50)	

Where, RH is Relative humidity, BSS is Bright sun shine hours during the period and the figures in parenthesis indicate percent rainfall of evaporative demand.

Table 3. Mean, minimum and maximum and standard deviation (SD) values of various parameters studies in 60 peanut cultivars

	Days for flowering Initiation		Days to 50% flowering		Total flowers produced in first 10 days		RWC at 70DAS		SCMR at 70DAS		SLA at 70DAS	
	P	RF	P	RF	P	RF	P	RF	P	RF	P	RF
Mean	23.2	26.3	27.7	31.2	61.7	57.3	95.6	84.9	37.5	39.5	185	147
Min	19.3	23	24.5	26	19	10	92.3	71.5	25.3	27.9	135	112
Max	28	32.5	34	37.7	111	105	97.1	91.8	44.4	50.4	293	210
SD	2.27	2.21	2.18	3	24.5	26	0.86	4.43	4.02	4.27	34	16
	Number of leaves on main axis		Plant height (cm)		Number of pods/plant		Pod yield kg ha^{-1}		Fodder yield (kg ha^{-1})		HI	
	P	RF	P	RF	P	RF	P	RF	P	RF	P	RF
Mean	15.5	14.0	43.6	39.8	11.4	13.2	1260	1130	3330	2860	0.29	0.29
Min	13.0	11.0	30.8	28.1	7.9	7.4	530	390	930	1260	0.11	0.17
Max	18.7	17.2	56.4	55.3	18.4	18.1	2110	1700	6440	4520	0.41	0.42
SD	1.35	1.23	6.39	5.30	2.18	2.26	530	390	930	1260	0.11	0.17

Table 4. Analysis of variance among various physiological traits (Mean Sum Square values)

		Initiation of flowering (days)	**50% flowering (days)**	**Total flowers**	**RWC (%)**	**SCMR**	**SLA**
Effects	**DF**						
Treatment	1	872.7**	1123.6**	1690**	10223.9**	358.2**	130267**
Variety	59	26.2**	34.5**	3343.3**	29.9**	74.2**	3112**
Treatment x Variety	59	3.9**	6.8**	487.4**	31.4**	28.9**	1221**
Residual	240	2.3	3.6	0.6	3	9.6	78
Total	359						
Effects	**DF**	**No.of leaves on main axis**	**Plant Height**	**No. of pods/plant**	**Pod wt/plant**	**Foddrwt/plant**	**HI**
Treatment	1	210.8**	1336.9**	285.2	32.3*	162**	5.53391
Variety	59	7.6**	193.3**	21.9	21.8**	197.3**	0.01652**
Treatment x Variety	59	2.4**	13.5	7.7	5.7	23.1	0.00283*
Residual	240	1.5	12.2	7.1	5.5	19.3	0.00202
Total	359						

* and ** indicates significance at 0.05 and 0.01 level (P value<0.05, 0.01)

Table 5. Peanut cultivarswithdesirable physiological traits under rain-fed and protected conditions during *Kharif*2012

	Protected	**Rainfed**
Traits	**Desirable cultivars**	**Desirable cultivars**
Pod yield	ICGS 5, JGN 23, AK 265, GG 5, GG 11, GG 16, GG 20, Girnar 1, AK 159, ICGV 86325, CSMG 9510, HNG 10, M 13, BAU 13, JAL 42, SB XI, DSG 1 (>1450 kg ha^{-1})	ICGS 5, JGN 23, AK 265, GG 5, GG 6, GG 7, GG 11, GG 16, Girnar 1, Gangapuri, AK 159, SBXI, TMV 2, DRG 1, DRG 12, JL 286 (>1300 kg ha^{-1})
HI	TG 51, JAL 42, JGN 23, Girnar 1, SB XI, ICGS 44, GG 2, TAG 24, JL 286, JL 24, TG 37A, ICGS 5, DRG 1, HNG 10,	TG 51, JAL 42,JGN 23,Girnar 1,SB XI,ICGS 44, GG 2, TAG 24,JL 286,GG 5,GG 7, DRG 12,TLG 45,ICGS 37,

	(> 0.33)	DRG 1, Gangapuri,TMV 2 (> 0.33)
SCMR	GG 20, DRG 17, ICGV 86031, ICGS 37, ICGS 44, CSMG 9510, GG8, B 95, SG 99,Somnath, HNG 69,Kadiri 9, TMV 2, TLG 45, CSMG 884, BAU 13, Kadiri3 (>40)	TPG 41, SG 99, DRG 12, Kadiri 9, GG 7, ICGV 86325, LGN 2, ICGS 44, ICGV 86031, GG 11, DRG 17, ICGV 86590, JL 24, ICGS 5, ICGS 37, M 335, TG 37A, Kadiri 5, TKG 19A, GG 8, B 95, Somnath, CSMG 9510, GG 20 (>40)
SLA	ICGS 37, ICGV 86031, ICGV 86590, ICGV 88448, CSMG 884, Somnath, GG 11, M 13, ICGS 44,B 95, TPG41, ICGV 91114 (<160 cm^2g^{-1})	ICGS 37, ICGV 86031, ICGV 86590, ICGV 88448, CSMG 884, Somnath, GG 11, M 13, ICGS 44,TKG 19A, Girnar 2, Kadiri 9, DRG 12, CSMG 9510, DSG 1, TAG 24, DRG 17, SG 99, Girnar 3, HNG 10, M 335, GG 14, ICGV 86325, Pratapmungfali 1 (<141 cm^2g^{-1})
Early Flowering	JGN 23, GG 2, GG 4, GG 7, GG 8, Girnar 1, JL 24, JL 286, Kadiri 5, JAL 42, SB XI, AK 159, Gangapuri, TMV 2, Chico, DRG 1, TAG 24, ICGS 37, ICGV 91114, TKG 19A, (within 26 days at 506 C°D)	JGN 23, GG 2, GG 6, GG 7, GG 8, Girnar 1, JL 24, JL 286, Kadiri 5, JAL 42, SB XI, AK 159, Gangapuri, TMV 2, Chico, Pratapmungfali 1, GPBD 4, ICGS 5, TG 51, TLG 45, SG 99 (within 30 days at 565 C°D)
Early maturity	Chico,JGN23, GG 2, GG 4, GG 5, GG 6, GG7, GG8,Girnar 1, JL 24, JL 286, Gangapuri , TMV2, SB XI, AK 159, Pratapmungfali1, , ICGS 5, ICGS 37, ICGS 44, ICGV 91114, ICGV 86031,JAL 42, DRG 1, TAG 24, TG 37A, TPG41, TLG 45, TG51, VRI 2, Kadiri5, (within 113 days at 2130 C°D)	Chico, JGN23,GG 2, GG 4, GG 5, GG 6, GG7,GG8, Girnar 1, JL 24, JL 286,Gangapuri, TMV2, SB XI, AK 159, Pratapmungfali1, ICGS 5, ICGS 37, ICGS 44, ICGV 91114, ICGV 86031, JAL 42,DRG 1,TAG 24, TG 37A, TPG41,TLG 45, TG51, VRI 2, Kadiri5, GPBD 4, SG 99, (within 112 days at 2114 C°D)

Table 6. Yield trait wise classification of cultivars for drought tolerance

Trait and trait combinations	**Treatment conditions**	**List of cultivars**
High yield and HI and early flowering,	P	JGN23, Girnar 1, JAL 42, SB XI
	RF	JGN 23, GG 7, Girnar 1, SB XI, JL 286, GG 11, Gangapuri, TMV 2
High yield and SCMR	P	GG 20, CSMG 9510, BAU13
	RF	ICGS 5
High SCMR and Low SLA	P	ICGV 86031, ICGS 37, ICGS 44, CSMG 884 B 95, Somnath
	RF	Kadiri 9, SG 99, ICGV 86031, ICGV 86325, ICGV 86590, Somnath, GG 11, M 335, TKG 19A, ICGS 37, CSMG 9510
High yield and early Maturity	P	ICGS 5, JGN 23, GG 5, AK 159, JAL 42, SB XI, Girnar 1,
	RF	ICGS 5, JGN 23,GG 5, GG 6,GG 7, Girnar 1, Gangapuri,AK 159,SBXI,TMV 2,DRG 1,JL 286
High yield and HI, and early flowering and maturity	P	JGN23, Girnar 1, JAL 42, SB XI
	RF	JGN23, Girnar 1, SB XI

*****P and RF are protected and Natural drought (rainfed) treatments, respectively.

CONCLUSION

Among the four botanical groups, Spanish bunch group was found best with desirable traits for rain-fed drought-prone condition. The cultivars likeICGS 5, JGN 23, AK 265, GG 5, GG 11, GG 16, Girnar 1, AK 159, SBXI showed > 1300 kg ha^{-1} pod yield under both the conditions and found suitable for rain-fed cultivation. Combination of high SCMR with low SLA, high HI and low SLA, high yield and HI and early flowering behaviour are required for high physiological plasticity for drought tolerance and hence are ideal for both protected and rain-fed cultivation. Cultivars screened for natural drought are of immense use in the areas where drought is occurs often in semi-arid regions of the world. The study concludes that the cultivars with early flowering, high SCMR,low SLA, high pod yield and HI along with early maturity traitpossess drought tolerance mechanism and were considered as highly suitable for rain-fed cultivation.Among different habit groups, Spanish bunchgroup was found more suitable.The cultivars *viz*. JGN 23, SB XI, and Girnar 1 showed most of the desirable characters indicating high physiological plasticity and hence can be of immense use for rain-fed cultivation.

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RESEARCH ARTICLE

SUCKER TYPE, HARVESTING PERIOD AND AGRO-MORPHOLOGICAL PARAMETERS FOR FASTER MULTIPLICATION OF *ALOE VERA* L.

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Abstract: *Aloe barbadensis* Miller has been used traditionally for heeling as a natural medicine. This crop attracting global market especially for cosmetic, pharmaceutical and food industry, therefore, greater demand for produce. It can be met out only through large scale cultivation. For this we need sufficient quality planting material of particular elites rich in bioactive chemicals, true to type and having short gestation period. Suckers are the primary and suitable source as propagating material. Agro-morphological parameters were observed maximum at four pair leaves from nine months harvest and minimum at one pair leaf from seven-month harvest. Maximum leaf and sucker were also observed in three and four pairs leaves at nine months after transplanting under well managed condition. The bacterial soft rot disease causes significant losses to the crop was also observed in the field. The leaf and sucker yield were increased with increase the sucker sizes.

Keywords: Aloe vera, Harvesting stage, Leaf yield, Soft rot, Sucker

INTRODUCTION

Aloe vera popularly known as aloe, is a xerophytic succulent perennial plant belongs to family Asphodelaceae and represented in the Liliaceae family, although it has its own family known as Alliaceae (Eshun and He, 9). The genus *Aloe* consisting more than 300 species, but there are only two species, *Aloe barbadensis* Miller and *Aloe aborescens* grown commercially (Tawaraya *et al.*, 17). *Aloe barbadensis* Miller and *A. chinensis*are considered the most biologically active species in India (Tawaraya *et al.,* 17). It is grown under subtropical and tropical parts of the world in various countries. The leaves are composed of three layers, an inner gel, a yellow sap and the outer thick layer of 15-20 cells called as rind (Eshun and He, 9; Surjushe *et al.,* 16). *Aloe vera* contained 98.5% water and the two major liquid sources are yellow latex and clear gel present in large parenchymatic cells of the leaf (Dagne *et al.,* 7). The plants generally grow 60 to 100 cm height in typical rosette shape with radically arranged leaves in two or three circles. The succulent leaves are pea green colour, 30-50 cm long and 10 cm broad at the base in triangular shape with spikes along the edges. *Aloe* leaf gel is major economical constituent used in variety of cosmetics including shampoos, sun blocks, lotions and skin creams. *Aloe* has been marketed as a remedy for healing wounds, burns, minor cuts, coughs, ulcers, gastritis, diabetes, cancer, headaches, arthritis, immune-system deficiencies and many other conditions when taken internally and externally (Rajeswari *et al.*, 15). There is a huge demand of aloe leaf for industry purpose (Aggarwal and Barna, 1) with an estimated annual market of $13 billion and which will increase up to 40% in coming five years (Grace *et al.,* 10). This global demand cannot be met through wild harvest. *Aloe* is a hardy species which demands less care for its cultivation and does not require very fertile land and lesser prone to pest and diseases. In India vast area remains underutilized due to low fertility and lack of resources, *Aloe* can be a good option for such areas for fetching high value. The presence of male sterility in flower is a major hurdle in rapid multiplication of crop by seeds. Therefore, suckers or offshoots are the primary source of propagation for commercial cultivation of crop. Generally, it produced 3-5 suckers per plant and all sized suckers are chosen carefully, dugout without damaging the parent plant, and directly planted in the field. The fertile seeds are derived through cross pollination (Botes *et al.,* 5) but it involves high heterogeneity of seedlings and maintaining cost because of frequent natural hybridization of the species (Alagukannan and Ganesh, 2). Seed propagated plants having long gestation period (3-4 years for harvestable stage) as compare to suckers in one year (Cristiano *et al.,* 6). Keeping this in view, the present work was taken on disease incidence and cost-effective propagation through suckers for easy, true to type and short gestation period using variant of sucker's sizes.

MATERIALS AND METHODS

Experimental site

The experiment was carried out research farm of ICAR-Directorate of Medicinal and Aromatic Plants Research, Boriavi, Anand, Gujarat during harvesting season of the year 2017-18. The experimental farm is located at 22°35 'N and 72°55 'E at an altitude of about 45.1 m above MSL.

Plant materials

Planting material of aloe vera was collected from previous crop grown on same farm at different location. The suckers were planted at a spacing of 60 × 60 cm with four different treatment i.e. one pair leaf, two pair leaves, three pair leaves and four pair

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leaves with six replications each in September, 2017. Harvesting was done at different time interval i.e. after seven, eight and nine months of transplanting.

Performance of yield contributing parameters and sucker's development

The plants selected for the analysis were uniform in age and five plants from each treatment were randomly chosen for observation. Observations for these four treatments were carried out for leaf yield, yield contributing and sucker's parameters. The values of different observations obtained from these plants were averaged to get the mean value separately according to treatments.

Bacterial soft rot disease

The experimental field was regularly visited and the soft rot disease was observed based on the symptoms. The observation on symptoms and disease incidence was measured on one; two; three and four paired leaf suckers. The soft rot incidence was recorded by observing 100 plants. Percent disease incidence (DI) was determined using the formula:

Disease Incidence = (Number of infected plants / Total number of plants observed) x 100

Statistical analysis

The analysis of variance was done in randomized block design for various observations observed during experiment by using statistical software SAS 9.2 (Anon 2008). DMRT comparisons among the essential oil, compounds obtained from the germplasm including check and between the harvesting stages. The results were presented at 5% level of significance (P = 0.05). The critical difference (CD) values were calculated to compare the various treatment means.

RESULTS AND DISCUSSION

The performance of different yield contributing parameters with sucker types at different harvesting periods were observed in the present study (Table 1). Seven months after transplanting of suckers with four paired leaves had maximum survival (98.64%), plant height (57.20 cm), plant spread (1834.75 cm^2), number of mature leaves per plant (9.60), weight per plant (2.93 kg), weight of leaves per plant (2.76 kg), leaf length (50.76 cm), leaf width (5.74 cm), leaf diameter (13.97 mm), number of spines (20.60), weight of roots (99.33 g), number of roots (50.33) and root length (25.77 cm) followed by suckers with three paired leaves (89.23%, 49.81 cm, 1305.99 cm^2, 7.45, 2.01 kg, 1.94 kg, 41.56 cm, 4.80 cm, 12.31 mm, 18.60, 57.60 g, 37.80 and 23.62 cm), respectively. The maximum number of fresh leaves per plant and root diameter was observed in suckers with three paired leaves (3.31 and 2.65 mm, respectively) followed by suckers with two paired leaves (3.24 and 2.56, respectively). While the minimum survival (58.1%), plant height (39.56 cm), plant spread (656.20 cm^2), number of mature leaves per plant (5.82), weight of plant (0.37 kg), weight of leaves (0.35 kg), leaf length (33.78 cm), leaf width (3.02 cm), leaf diameter (10.31 mm), weight of roots (16.20 g), number of roots (21), root length (19.33 cm) and root diameter (1.76 mm) were found in suckers with one paired leaves and the minimum number of fresh leaves per plant (2.80) and number of spines (14.60) were observed in suckers with four paired and two paired leaves, respectively.

After eight months of transplanting suckers with four paired leaves had maximum survival (98.30%), plant height (71.53 cm), plant spread (2484 cm^2), number of mature leaves per plant (11.67), weight of plant (4.44 kg), weight of leaves (4.37 kg), leaf length (54.76 cm), leaf width (5.97 cm), leaf diameter (15.86 mm), number of spines (24), weight of roots (70 g), number of roots (40.67), root length (15.40 cm) and root diameter (3.28 mm) followed by suckers with three paired leaves for survival (85.37%), plant height (63.63 cm), plant spread (2061.90 cm^2), number of mature leaves per plant (8.67), weight of plant (2.39 kg), weight of leaves (2.34 kg), leaf length (50.60 cm), leaf diameter (14.06 mm), number of spines (21), weight of roots (51.33 g), number of roots (35.33) and root length (15.07 cm)and suckers with two paired leaves for leaf width (5 cm), root diameter (3.08 mm). The maximum number of fresh leaves per plant (3.00) was observed in suckers with three and two paired leaves, respectively, followed by suckers with four and one paired leaves (2.67). The minimum survival (57.14%), plant height (46.43 cm), plant spread (743.67 cm^2), number of mature leaves per plant (6.67), weight of plant (0.73 kg), weight of leaves (0.71 kg), leaf length (40.67 cm), leaf width (3.97 cm), leaf diameter (11.67 mm), number of spines (18), weight of roots (26 g), number of roots (31.67), root length (13.70 cm) and root diameter (2.82 mm) were observed in suckers with one paired leaves.

After nine months of transplanting suckers with four paired leaves had maximum survival (97.96%), plant height (72.33 cm), plant spread (2463 cm^2), number of mature leaves per plant (12), weight of plant (4.73 kg), weight of leaves (3.99 kg), leaf length (80.18 cm), leaf width (8.83 cm), leaf diameter (24.54 mm), number of spines (35.38), weight of roots (73 g), number of roots (42.39), root length (17.73 cm) and root diameter (3.42 mm) followed by suckers with three paired leaves (83.67%, 57.50 cm, 1983.33 cm^2, 9.00, 3.05 kg, 3.20 kg, 70.89 cm, 8.37 cm, 23.09 mm, 32.60, 54.33 g, 37.64, 17.67 cm and 3.34 mm), respectively. The maximum number of fresh leaves per plant (3.33) was observed in suckers with three and two paired leaves, respectively followed by suckers with four paired leaves (3.00). The minimum survival (56.46%), plant height (43.83 cm), plant spread (1279 cm^2), number of mature leaves per plant (7), weight of plant (0.69 kg), weight of leaves (0.70 kg), leaf length (40.71 cm), leaf width (4.33 cm), leaf diameter (12.39 mm), number of spines

(19.58), weight of roots (29 g), number of roots (32.06), root length (15.34 cm) and root diameter (2.86 mm) were observed in suckers with one paired leaves. The plant height, number of tillers per plant, leaf length and number of leaves per plant increased with an increase in the harvesting period as observed in *Pennisetum pedicellatum* Trin. under Ethiopian condition (Asmare *et al.,* 4). In forage turnip (*Brassica rapa* L.) root length, root diameter, root yield and leaf yield increased with delay in harvesting time (Tiryakioglu and Turk, 18).

The performance of sucker's development for different sucker types at different harvesting period showed that after seven months of transplanting the suckers with four paired leaves had maximum number of suckers (6), length of sucker (29.87 cm), weight of sucker (943.67 g) and number of leaves per sucker (5.44) followed by suckers with three paired leaves (4.40, 25.18 cm, 597 g and 5.18, respectively).The maximum diameter of suckers (2.73 mm) was observed in suckers with three paired leaves followed by suckers with four paired leaves (2.59 mm). While the minimum numbers of suckers (1.25), length of sucker (12.41 cm), weight of sucker (19.50 g), diameter of suckers (1.30 mm) and number of leaves per sucker (3.40). After eight months of transplanting the suckers with four paired leaves had maximum number of suckers (8.33), length of sucker (35.52 cm), weight of sucker (278.92 g), diameter of suckers (9.52 mm) and number of leaves per sucker (7) followed by suckers with three paired leaves (Fig. 1). The minimum numbers of suckers (2), length of sucker (15.43 cm), weight of sucker (36.83 g), diameter of suckers (5.45 mm) and number of leaves per sucker (3.90) were observed in suckers with one paired leaf. With the increase of harvesting duration for plant growth was also increased with effective use of environmental factors which resulted in increase of plant height, leaf length, leaf diameter, number of leaves and leaves weight in *Aloe barbadensis* Miller (Hazrati *et al.,* 11). Over all the crop (mature leaves) and suckers were started harvesting regularly at seven, eight and nine months after transplanting. However, Aloe vera crop is ready to harvest after 18 months of sowing (Cristiano *et al.,* 6; Das and Chattopadhay, 8; Rajeswari *et al.,* 15).

Table 1. Performance of different yield contributing parameters at different harvesting period and sucker types.

Sucker size/Harvesting period	Survival (%)	Plant height (cm)	Average spread (cm^2)	No. of fresh leaves/ plant	No. of mature leaves/ plant	Plant weight (kg)	Leaves weight (kg)	Leaf length (cm)	Leaf width (cm)	Leaf diameter (mm)	No. of spines/ leaf	Root weight/ plant (g)	No. of roots/plant	Root length (cm)	Root diameter (mm)
Seven months after transplanting															
One pair leaf	58.16^{d}	39.56^{d}	656.20^{d}	3.20^{c}	5.82^{d}	0.37^{d}	0.35^{c}	33.78^{d}	3.02^{cd}	10.31^{c}	14.80^{c}	16.20^{d}	21.00^{c}	19.33^{bc}	1.76^{c}
Two pairs leaves	82.88^{c}	44.70^{c}	935.36^{c}	3.24^{b}	6.42^{c}	1.38^{c}	1.28^{b}	36.66^{c}	3.72^{c}	10.97^{c}	14.60^{c}	53.60^{c}	37.60^{b}	20.64^{b}	2.56^{ab}
Three pairs leaves	89.23^{b}	49.81^{b}	1305.99^{b}	3.31^{a}	7.45^{b}	2.01^{b}	1.94^{ab}	41.56^{b}	4.80^{b}	12.31^{b}	18.60^{b}	57.60^{b}	37.80^{b}	23.62^{ab}	2.65^{a}
Four pairs leaves	98.64^{a}	57.20^{a}	1834.75^{a}	2.80^{d}	9.60^{a}	2.93^{a}	2.76^{a}	50.76^{a}	5.74^{a}	13.97^{a}	20.60^{a}	99.33^{a}	50.33^{a}	25.77^{a}	2.52^{b}
Eight months after transplanting															
One pair leaf	57.14^{d}	46.43^{d}	743.67^{d}	2.67^{b}	6.67^{c}	0.73^{d}	0.71^{d}	40.67^{c}	3.97^{c}	11.67^{d}	18.00^{bc}	26.00^{d}	31.67^{c}	13.70^{bc}	2.82^{b}
Two pairs leaves	73.47^{c}	58.73^{c}	1475.58^{c}	3.00^{a}	7.67^{bc}	1.77^{c}	1.73^{c}	49.02^{bc}	5.00^{b}	13.19^{c}	20.00^{b}	33.67^{c}	30.33^{bc}	14.73^{b}	3.08^{ab}
Three pairs leaves	85.37^{b}	63.63^{b}	2061.90^{b}	3.00^{a}	8.67^{b}	2.39^{b}	2.34^{b}	50.60^{b}	5.80^{ab}	14.06^{b}	21.00^{ab}	51.33^{b}	35.33^{b}	15.07^{ab}	2.83^{b}
Four pairs leaves	98.30^{a}	71.53^{a}	2484.00^{a}	2.67^{b}	11.67^{a}	4.44^{a}	4.37^{a}	54.76^{a}	5.97^{a}	15.86^{a}	24.00^{a}	70.00^{a}	40.67^{a}	15.40^{a}	3.28^{a}
Nine months after transplanting															
One pair leaf	56.46^{d}	43.83^{c}	1279.00^{d}	2.67^{b}	7.00^{c}	0.69^{d}	0.70^{d}	41.71^{c}	4.33^{c}	12.39^{c}	19.58^{d}	29.00^{d}	32.06^{c}	15.34^{b}	2.86^{b}
Two pairs leaves	70.41^{c}	52.80^{bc}	1588.02^{c}	3.33^{a}	8.00^{bc}	2.71^{c}	2.64^{c}	67.26^{bc}	7.88^{b}	20.72^{b}	28.40^{c}	36.67^{c}	33.24^{c}	16.15^{b}	3.04^{ab}

Three pairs leaves	83.67^{b}	57.50^{b}	1983.33^{b}	3.33^{a}	9.00^{b}	3.05^{bc}	3.20^{b}	70.89^{b}	8.37^{ab}	23.09^{ab}	32.60^{bc}	54.33^{b}	37.64^{bc}	17.67^{a}	3.34^{a}
Four pairs leaves	97.96^{a}	72.33^{a}	2463.64^{a}	3.00^{ab}	12.00^{a}	4.73^{a}	3.99^{a}	80.18^{a}	8.83^{a}	24.54^{a}	35.38^{a}	73.00^{a}	42.39^{a}	17.73^{a}	3.42^{a}

Means with the same letter (superscript) in the columns do not showing significantly different (P = 0.05) – (Duncan Multiple Range Test).

Table 2. Performance of sucker's development at different harvesting period and sucker types.

Sucker size/Harvesting period	No. of suckers/plant	Length of sucker (cm)	Weight of sucker (gm)	Diameter of suckers (mm)	No. of leaves/suckers
Seven months after transplanting					
One pair leaf	1.25^{c}	12.41^{c}	19.50^{d}	1.30^{d}	3.40^{c}
Two pairs leaves	3.60^{b}	22.33^{bc}	247.00^{c}	2.44^{c}	4.72^{b}
Three pairs leaves	4.40^{ab}	25.18^{ab}	597.00^{b}	2.73^{a}	5.18^{ab}
Four pairs leaves	6.00^{a}	29.87^{a}	943.67^{a}	2.59^{b}	5.44^{a}
Eight months after transplanting					
One pair leaf	2.00^{d}	15.43^{c}	36.83^{d}	5.45^{c}	3.90^{c}
Two pairs leaves	6.00^{c}	27.53^{b}	125.48^{c}	7.74^{b}	5.41^{bc}
Three pairs leaves	7.00^{b}	28.93^{b}	199.62^{b}	7.51^{b}	6.00^{b}
Four pairs leaves	8.33^{a}	35.52^{a}	278.92^{a}	9.52^{a}	7.00^{a}
Nine months after transplanting					
One pair leaf	1.86^{c}	15.58^{c}	37.33^{d}	5.59^{c}	3.73^{d}
Two pairs leaves	7.45^{b}	40.78^{b}	186.29^{c}	10.63^{b}	4.11^{c}
Three pairs leaves	9.70^{ab}	44.60^{ab}	305.96^{b}	11.24^{ab}	6.73^{b}
Four pairs leaves	10.32^{a}	45.29^{a}	354.23^{a}	12.39^{s}	7.11^{a}

Means with the same letter (superscript) in the columns do not showing significantly different (P = 0.05) – (Duncan Multiple Range Test).

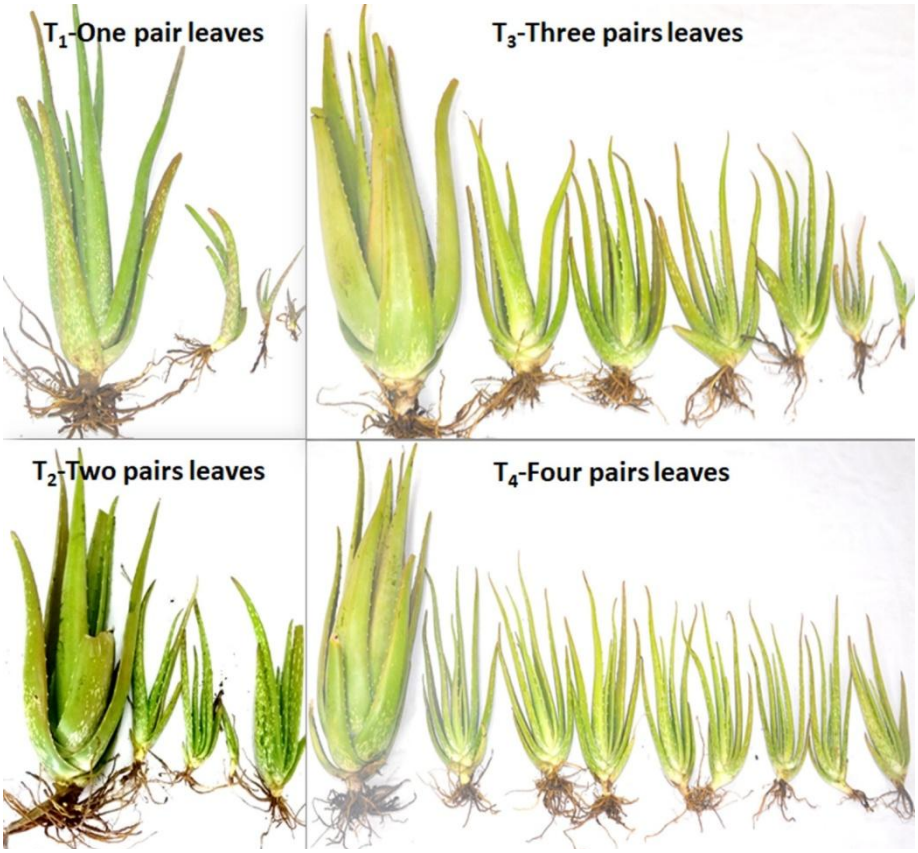

Fig. 1. Number of suckers produced at eight months after transplanting by different sucker types used for plantation.

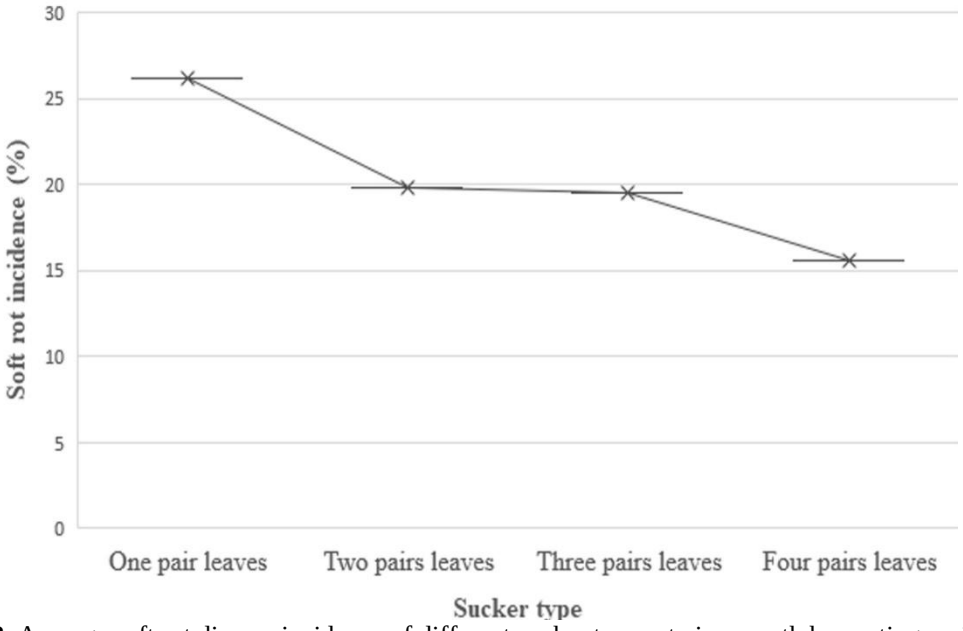

Fig. 2. Average soft rot disease incidence of different sucker types at nine month harvesting period.

Fig. 3. Soft rot disease incidence in one pair and two pair leaf suckers transplanted in field at nine month harvesting period (rainy season).

After nine months of transplanting the suckers with four paired leaves had maximum number of suckers (10.32), length of sucker (45.29 cm), weight of sucker (354.23 g), diameter of suckers (12.39 mm) and number of leaves per sucker (7.11) followed by suckers with three paired leaves (9.70, 44.60 cm, 305.96 g, 11.24 mm and 6.73, respectively). The minimum numbers of suckers (1.86), length of sucker (15.58 cm), weight of sucker (37.33 g), diameter of suckers (5.59 mm) and number of leaves

per sucker (3.73) were observed in suckers with one paired leaf. In "Sugarloaf" pineapple the plant height, number of leaves per plant, slip number per plant, crown weight and crown length were found maximum in large sized suckers (Norman, 13). In Chrysanthemum, large sized suckers and delayed harvesting gave maximum number of flowers per plant, flower diameter and weight of flower (Anjum *et al.,* 3). At same time soft rot diseases symptoms were observed. The incidence of disease had negative relationship with increase sucker leaf pairs during ninth months of harvesting (Fig. 2). The disease incidence observed severely during the rainy season due to high moisture (Fig. 3). The incidence of disease observed ranging from 15 to 26% and varied in different leaf paired suckers, this might be due to poor plant development at early sucker types and nine-month coincidence with rainfall (Mandal and Maiti. 12). The role of free water and anaerobiosis weakening the host resistance in potato (Perombelon, 14).

Quality planting material production of Aloe vera play important role than leaf production due to dependence. The global market demand curve rising with continually for Aloe vera produce, therefore, there is a need for suitable propagation technique for faster multiplication with higher leaf production. Maximum leaf and sucker were also observed in three and four pairs leaves at nine months after transplanting. The leaf and sucker yield were increased with increase the sucker sizes.

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RESEARCH ARTICLE

EVALUATION OF THIAMETHOXAM 25% WG AGAINST JASSID, APHID AND WHITEFLY ON OKRA

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Abstract: Okra, *Abelmoschus esculentus* (L) Moench is an important vegetable crop, grown in tropical and sub tropical parts of the world. India is the world's second largest producer of vegetables next to China. The experiment was conducted at Entomological Experimental Field, JNKVV, Jabalpur, using RBD, during the summer season of 2016. The Plot size was 3x5 m., crop was sown in the second week of April. It can be concluded that comparing the Thiamethoxam 25% WG @ 200 gm/ ha can be recommended for reducing the infestation due to jassids, aphids and whiteflies on okra. Perusal of the healthy fruit yield data revealed that significantly highest among all the treatments was registered by Thiamethoxam 25% WG @ 200 gm/ ha. (42.71 q/ ha). All the insecticidal treatments were significantly superior then untreated control, which registered the lowest healthy fruit yield of 23. 45 q/ ha.

Keywords: Aphids, Jassids, Okra, Thiamethoxam, Whiteflies

INTRODUCTION

Okra, *Abelmoschus esculentus* (L) Moench is an important vegetable crop, grown in tropical and sub tropical parts of the world. India is the world's second largest producer of vegetables next to China. Okra belongs to family Malvaceae and it has multipurpose uses. Its fruit are consumed as green vegetable and mucilaginous extracts of green stem and roots are used for clarifying sugar cane juice in "Gur" manufacturing in India. Okra is widely cultivated in plans of the India with acreage of 524.0 mha. and production 6203.0 MT and productivity 11.83 MT/ha. In Madhya Pradesh, okra is grown in 26.51 mha. area with production of 305.90 MT and 11.5 MT/ ha productivity . Okra crop is usually heavily infested by various insects pests, which affect the crop both, quantitatively and qualitatively. In early stage of its growth considerable damage is caused by jassid, *Amrasca biguttula biguttula* resulting in discolouration, curling and deformation of leaves and deterioration of yield quantity and quality. The estimated 22.6 per cent losses on account of jassids. In later stage Shoot and fruit borer (*Earias vittella* and *E.insulana*) causes considerable damage to okra shoots in early stage and later on to fruits. There is a long list of insect pests on okra crop . Reported *Amrasca biguttulla biguttula*, *E. vittella*, *Melanagromyza hibisci*, *Aphis gossypii*, *Bemisia tabaci*, *Nezara viridula*, *Tetranychus telarius* Auct. *Dysderus koenigii*, *Mylabris pusiaulata*, *Anomis flava, Myllocerus undecimpustulalus*, Var Maculosus and *Sylepta derogata*, on okra crop, in Gwalior (M.P.) Among these insect pests, shoot and fruit borer, far as *E. vittella* (Fab.) is the most destructive pest causing considerable damage to okra crop in all stage of its growth. More severe damage has been reported by the workers who stated 12.09 and 40.37 per cent damage in okra by *E.vitlella* during mansoon and summer seasons respectively. The observed 58.90 per cent avoidable fruit losses by shoot and fruit borer, *Earias vitlella* (Fab.) on okra crop. *Earias villella* is not only a serious pest of cotton and okra but it also causes considerable damage to other malvaceous plants.

MATERIALS AND METHODS

The experiment was conducted at Entomological Experimental Field, JNKVV, Jabalpur, using randomized block design, during the summer season of 2016. The Plot size was 3x5 m. The okra crop was sown in the second week of April, variety hybrid no.319 with treatment seven. All agronomical practices were adopted. The treatment consisted of spraying the crop three with Four Doses of Thiamethoxam 25%WG (80, 100,120 and 200 gm/ ha) along with two doses of a commonly recommended insecticide viz. Azadiractin 0.15% (400ml /ha) and Imidacloprid 17.8% SL (120ml/ha) were sprayed to work out their Bio-efficacy against jassid, aphid and whitefly of okra. Observations were made regularly on incidence of Jassid, Aphid and Whitefly after the germination of okra crop. First spray was given after the appearance of jassid and aphid in sufficient numbers. Pre-treatment observations on jassid aphid and whitefly were recorded 24 hours before treatment and post treatment observations were recorded on six leaves per plant 2 upper, 2 middle and 2 lower from ten randomly selected plants per plot. These observations were taken on 1st, 5th, 7th and 10th days after each spray of insecticides. The data of actual population of jassid, aphid and whitefly were transformed into square root transformation and statistically analyzed in randomized block design as per the method.

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Observations on yield were taken at each picking after the spray. The data on healthy marketable fruit yield per plot (total of all 12 pickings) was converted in to per hectare yield (q/ha.) and statistically analyzed. Observation were also recorded on population of natural enemies of jassids aphids and white fly immediately before the first spray and 1st, 5th,7th and 10th days after each spray of insecticides. The actual population of natural enemies was transformed into square root transformation and statistically analyzed. Number and weight of healthy and damaged fruits were recorded 1,5,7,10 days after the first second and third sprays. The data were subjected to analysis of variance after angular transformation, at 5% level of significance.

Table 2. Details of Treatments

Treatment code	Treatments	a.i. (gm/ ml) /ha.	Dose gm/ ml/ ha.
T1	Thiamethoxam 25% WG	20	80
T2	Thiamethoxam 25 %WG	25	100
T3	Thiamethoxam 25 %WG	30	120
T4	Thiamethoxam 25 %WG	50	200
T5	Azadiractin0.15%	-	400
T6	Imidacloprid 17.8 % SL	21.36	120
T7	Control	-	-

RESULTS

Four Doses of Thiamethoxam 25%WG (80, 100,120 and 200 gm/ ha) along with two doses of a commonly recommended insecticide viz. Azadiractin 0.15% (400ml /ha) and Imidacloprid 17.8% SL (120ml/ha) were sprayed to work out their Bio-efficacy against jassid, aphid and whitefly of okra.

Jassid

The data on jassid population presented in Table 4 indicated that significantly lower population of jassids (29.32 jassids/ 60 leaves) among all the treatments was observed in Thiamethoxam 25% WG @ 200 gm/ha. All the other insecticidal treatments were also registered significantly lower population then untreated control (148.51 jassids/ 60 leaves). Among the other insecticidal treatments viz. Thiamethoxam 25% WG @100 gm/ ha., Thiamethoxam 25% WG @ 120 gm/ ha., Imidacloprid 17.8% SL @ 120ml/ ha, and Azadiractin 0.15%@400ml/ha, populations of jassids were at par to each other and ranged between 50.30 to 57.24 jassids/ 60 leaves. All these treatments were significantly superior then Thiamethoxam 25% WG @ 80 gm/ ha., which registered the population of 87.09 jassids/ 60 leaves, However it was also having significantly lower population as compared to untreated control. Similar finding the basis of overall mean of three sprays, all the insecticidal treatments significantly reduced the jassid population as compared to control (127.50 jassids/30 leaves). Among the treatments, imidacloprid 17.8% SL @ 35.6 g a.i./ha. was found to be significantly effective among all the treatments as it recorded lowest jassid population (31.72 jassids/30 leaves). The next effective treatment was difenthiuron 50 WP @ 300 g a.i./ha (40.77 jassids/30 leaves) followed by imidacloprid 17.8% SL @ 17.8 g a.i./ha (50.66 jassids/30 leaves) and thiamethoxam 25% WG @ 25 g a.i./ha (51.83 jassids/30 leaves) but found at par to each other. Emamectin benzoate 5% SG @ 12 g a.i./ha (68.80 jassids/30 leaves) and emamectin benzoate 5% SG @ 10 g a.i./ha (79.88 jassids/30 leaves) were the next group of better treatments. Treatment NSKE 5% @ 750 g a.i./ha (93.36 jassid/30 leaves) although found least effective, but it was significantly superior to control . In conformity to the present findings, also reported that imidacloprid 17.8% at 40 g a.i. was found most effective.

Aphid

The data on aphid population presented in Table 5 indicated that significantly lower population of aphids (14.81 aphids/ 60 leaves) among all the treatments was registered by Thiamethoxam 25% @ WG 200 gm/ ha. All the other insecticidal treatments were also registered significantly lower population then untreated control (83.12 aphids/ 60 leaves). Among the other insecticidal treatments viz. Thiamethoxam 25% WG @100 gm/ ha., Thiamethoxam 25% WG @ 120 gm/ ha., Azadiractin 0.15%@400ml/ha and Imidacloprid 17.8% SL @ 120ml/ ha, populations of aphids were at par to each other and ranged between 27.28 to 29.41 aphids/ 60 leaves. All these treatments were superior then Thiamethoxam 25% WG @ 80 gm/ ha., which registered the population of 45.08 aphids/ 60 leaves however it was also having significantly lower population as compared to untreated control. The finding is in agreement with the findings the aphid population started to decline and reached to 22.45 aphids per leaf at September end in both the years of study. The performance of imidacloprid to reduce the population of aphid is good because of its systemic property and other hand investigation on neonicotinoid molecules against okra aphid is in line with the finding of. The aphid appeared in the second week of September with an average population of 1.42 mean aphid/leaf. The aphid population peaked is

in the second week of October (25.87 mean aphid/leaf).

Whitefly

The data on White fly population presented in Table 6 indicated that significantly lower population of white fly (15.53 whiteflies/ 60 leaves) among all the treatments was registered by Thiamethoxam 25% @ WG 200 gm/ ha. All the other insecticidal treatments were also registered significantly lower population then untreated control (46.15 whiteflies/ 60 leaves). Among the other insecticidal treatments viz. Thiamethoxam 25% WG @100 gm/ ha., Thiamethoxam 25% WG @ 120 gm/ ha., Azadiractin 0.15%@400ml/ha and Imidacloprid 17.8% SL @ 120ml/ ha, populations of whiteflies/ were at par to each other and ranged between 22.63 to 25.85 whiteflies/ 60 leaves. All these treatments were superior then Thiamethoxam 25% WG @ 80 gm/ ha., which registered the population of 33.28 whiteflies / 60 leaves however it was also having significantly lower population as compared to untreated control. Similarly On the basis of overall mean of third spray, imidacloprid 17.8% SL @ 35.6 g a.i./ha. was found to be significantly effective among all the treatments as it recorded lowest whitefly population (7.00 whiteflies/30 leaves). The next effective treatment was difenthiuron 50 WP @ 300 g a.i./ha (13.75 whiteflies/ 30 leaves) followed by imidacloprid 17.8% SL @ 17.8 g a.i./ha (20.08 whiteflies/30 leaves) and thiamethoxam 25% WG @ 25 g a.i./ha (20.92 whiteflies/30 leaves) but both were found at par to each other. Emamectin benzoate 5% SG @ 12 g a.i./ha (28.58 whiteflies/30 leaves) and emamectin benzoate 5% SG @ 10 g a.i./ha (36.50 whiteflies/30 leaves) were the next better treatments, while NSKE @ 750 g a.i./ha (43.92 whiteflies/30 leaves) was the least effective. All the insecticidal treatments have significantly reduced the whitefly population as compared to control (54.17 whiteflies/30 leaves). Similarly also reported that imidacloprid 17.8 SL at 25 g a. i./ha was found effective against jassid and whiteflies, while thiamethoxam also provided similarly level of protection as that of imidacloprd .

Healthy Fruit Yield

Perusal of the healthy fruit yield data (Table 7) revealed that significantly highest among all the treatments was registered by Thiamethoxam 25% WG @ 200 gm/ ha. (42.71 q/ ha). Next better treatments were Thiamethoxam 25% WG @ 120 gm/ ha., Azadiractin 0.15%@400ml/ha, Thiamethoxam 25% WG 100 gm/ ha. and Imidacloprid 17.8% SL @ 120ml/ ha having yield of 39.16 q/ha, 38.08 q/ha 37.90 q/ha and 36.38 q/ha respectively. These treatments were followed by Thiamethoxam 25% WG @ 80 gm/ ha. (31.17 q/ ha) which was significantly inferior as compared to above mentioned treatments. All the insecticidal treatments were significantly superior then untreated control, which registered the lowest healthy fruit yield of 23. 45 q/ ha. The maximum increased yield over control found in emamectin benzoate treated plots *i.e.* 72.27q ha. . Maximum marketable fruit yield of 71.35q /ha was recorded in acetamiprid, which was on par with imidacloprid (69.24q /ha), and thiamethoxam (65.42q/ha).

Effect of Treatments on Natural Enemies

In okra crop the only natural enemy recorded was the lady bird beetle. It is a major predator against soft bodied insects like jassids, aphids and whitefly etc. The data presented in Table 9 revealed that population of lady bird beetle was at par in all the treatments including the untreated control ranging from 0.33 to 0.47. Perusal the population data of lady bird beetle, it can be concluded that all the insecticidal treatments were have no adverse impact on the population of lady bird beetle. This finding is in agreement with the population of coccinellids ranged from 0.18 to 2.51 coccinellid/leaf. Altogether, 2 species of coccinellid predators which are *Coccinella transversalis* Fabr. and *C. septumpunctata* L were found associated with the aphid population. Observations regarding impact of neonicotinoids on population of natural enemies were furnished in the two rounds of spray of neonicotinoids on okra had no significant impact on the *Coccinellid*s (grubs and adults), *Chrysoperla* and spider population when compared with untreated control plot.

Table 4. Efficacy of Thiamethoxam 25% WG against jassid infesting okra

Treatment Code	Treatments	Dose gm/ ml/ ha	Mean population jassid/ 60 leaves				Over all Mean
			Pre treatment	After First Spray	After Second Spray	After Third Spray	
T1	Thiamethoxam 25% WG	80	135.96 (11.65)	117.40 (10.83)	91.70 (9.57)	52.17 (7.22)	87.09 (9.21)
T2	Thiamethoxam 25 %WG	100	138.9 (11.78)	80.93 (8.99)	42.38 (6.51)	27.60 (5.25)	50.30 (6.92)
T3	Thiamethoxam 25 %WG	120	140.5 (11.85)	85.55 (9.24)	43.4 (6.58)	32.78 (5.72)	53.91 (7.18)
T4	Thiamethoxam 25% WG	200	141.96 (11.91)	46.95 (6.85)	26.34 (5.13)	14.68 (3.83)	29.32 (5.27)

T5	Azadiractin 0.15%	400	135.2 (11.62)	90.48 (9.51)	44.85 (6.69)	36.4 (6.03)	57.24 (7.41)
T6	Imidacloprid 17.8 % SL	120	140.56 (11.85)	80.15 (8.95)	48.18 (6.94)	43.03 (6.55)	57.12 (7.48)
T7	Untreated Control	---	142.16 (11.91)	154.71 (12.43)	142.20 (11.92)	148.63 (12.19)	148.51 (12.18)
	SEm ±		0.23		-	-	0.40
	CD at 5%		N.S.		-	-	1.24

Figures in parentheses are √x square root transformed values, N.S.= Non-significant

Table 5. Efficacy of Thiamethoxam 25% WG against aphid infesting Okra

Treatment Code	Treatments	Dose gm/ ml/ ha	Mean population aphids/ 60 leaves				Over all Mean
			Pre treatment	After First Spray	After Second Spray	After Third Spray	
T1	Thiamethoxam 25% WG	80	77.36 (8.79)	58.36 (7.63)	46.10 (6.79)	30.77 (5.54)	45.08 (6.66)
T2	Thiamethoxam 25 %WG	100	83.23 (9.12)	42.53 (6.52)	26.32 (5.13)	13.00 (3.60)	27.28 (5.09)
T3	Thiamethoxam 25 %WG	120	81.13 (9.01)	44.79 (6.69)	26.30 (5.12)	12.44 (3.52)	27.84 (5.12)
T4	Thiamethoxam 25% WG	200	80.63 (8.98)	24.45 (4.94)	13.63 (3.69)	6.35 (2.51)	14.81 (3.72)
T5	Azadiractin 0.15%	400	77.03 (8.78)	47.55 (6.89)	29.83 (5.46)	10.19 (3.19)	29.19 (5.18)
T6	Imidacloprid 17.8 % SL	120	82.16 (9.06)	38.45 (6.20)	31.64 (5.62)	18.15 (4.26)	29.41 (5.36)
T7	Untreated Control	---	76.86 (8.77)	82.06 (9.05)	77.34 (8.79)	89.96 (9.48)	83.12 (9.11)
	SEm ±		0.12	-	-	-	0.40
	CD at 5%		N.S.	-	-	-	1.23

Figures in parentheses are √x square root transformed values, N.S.= Non-significant

Table 6. Efficacy of Thiamethoxam 25% WG against whitefly infesting Okra

Treatment Code	Treatments	Dose gm/ ml/ ha	Mean population whiteflies / 60 leaves				Over all Mean
			Pre treatment	After First Spray	After Second Spray	After Third Spray	
T1	Thiamethoxam 25% WG	80	42.66 (6.52)	38.78 (6.22)	32.51 (5.70)	28.55 (5.34)	33.28 (5.76)
T2	Thiamethoxam 25 %WG	100	43.66 (6.61)	32.05 (5.66)	21.01 (4.58)	14.83 (2.81)	22.63 (4.70)
T3	Thiamethoxam 25 %WG	120	47.00 (6.85)	32.47 (5.69)	21.9 (4.67)	15.65 (3.95)	23.44 (4.78)
T4	Thiamethoxam 25% WG	200	46.66 (6.81)	23.65 (4.93)	15.00 (3.87)	7.93 (2.81)	15.53 (3.88)
T5	Azadiractin 0.15%	400	48.00 (6.92)	32.76 (5.72)	22.41 (4.73)	15.85 (3.98)	23.67 (4.81)
T6	Imidacloprid 17.8 % SL	120	46.00 (6.76)	33.99 (5.83)	27.16 (5.21)	16.4 (4.04)	25.85 (5.03)
T7	Untreated Control	---	43.66 (6.56)	46.58 (6.82)	43.7 (6.61)	48.18 (6.94)	46.15 (6.79)
	SEm ±		0.35	-	-	-	0.23
	CD at 5%		N.S.	-	-	-	0.71

Figures in parentheses are √x square root transformed values, N.S.= Non-significant

Table 7. Efficacy of Thiamethoxam 25% WG on healthy fruit yield of okra

Treatment Code	Treatments	Dose gm/ ml/ ha	Total healthy fruit yield in all 12 picking (q/ha)			Over all Mean yield (q/ha)
			Replication one	Replication two	Replication three	
T1	Thiamethoxam 25% WG	80	32.96	30.37	30.18	31.17
T2	Thiamethoxam 25 %WG	100	35.37	38.88	39.44	37.90

T3	Thiamethoxam 25 %WG	120	36.29	40.0	41.20	39.16
T4	Thiamethoxam 25% WG	200	41.85	43.70	42.59	42.71
T5	Azadiractin 0.15%	400	37.03	37.40	39.81	38.08
T6	Imidacloprid 17.8 % SL	120	35	36.38	37.77	36.38
T7	Untreated Control	--	22.59	23.70	24.07	23.45
	SEm ±	--	--	--	--	0.83
	CD at 5%	--	--	--	--	2.54

Table 9. Effect of Thiamethoxam 25% WG on population of lady bird beetle.

Treatment Code	Treatments	Dose gm/ ml/ ha	Pre treatment	Mean population of lady bird beetles/ 60 leaves			Over all Mean
				After First Spray	After Second Spray	After Third Spray	
T1	Thiamethoxam 25% WG	80	0.00 (0.70)	0.33 (0.91)	0.41 (0.95)	0.33 (0.91)	0.36 (0.92)
T2	Thiamethoxam 25 %WG	100	0.00 (0.70)	0.41 (0.95)	0.33 (0.91)	0.66 (1.08)	0.47 (0.98)
T3	Thiamethoxam 25 %WG	120	0.00 (0.70)	0.33 (0.91)	0.33 (0.91)	0.41 (0.95)	0.36 (0.92)
T4	Thiamethoxam 25% WG	200	0.00 (0.70)	0.33 (0.91)	0.25 (0.86)	0.41 (0.95)	0.33 (0.91)
T5	Azadiractin 0.15%	400	0.00 (0.70)	0.25 (0.86)	0.41 (0.95)	0.41 (0.95)	0.36 (0.92)
T6	Imidacloprid 17.8 % SL	120	0.00 (0.70)	0.5 (1.0)	0.33 (0.91)	0.33 (0.91)	0.38 (0.94)
T7	Untreated Control	---	0.00 (0.70)	0.33 (0.91)	0.58 (1.04)	0.33 (0.91)	0.41 (0.95)
	SEm ±		0.00	-	-	-	0.03
	CD at 5%		N.S.	-	-	-	N.S.

Figures in parentheses are √x+ 0.5 square root transformed values, N.S.= Non-significant

CONCLUSION

From the above treatise it can be concluded that comparing the population of jassids, aphids, whiteflies and healthy fruit yield after application of all the treatments, Thiamethoxam 25% WG @ 200 gm/ ha was found significantly superior among all the doses and treatments applied. Next better treatments were Thiamethoxam 25% WG @120 gm/ ha., Azadiractin 0.15%@400ml/ha, Thiamethoxam 25% WG 100 gm/ ha. and Imidacloprid 17.8% SL @ 120ml/ ha. While Thiamethoxam 25% WG @ 80 ml/ ha was inferior to these treatments but it was found significantly superior to untreated control. It can be concluded that Thiamethoxam 25% WG @ 200 gm/ ha can be recommended for reducing the infestation due to jassids, aphids and whiteflies on okra.

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RESEARCH ARTICLE

CORRELATION AND PATH ANALYSIS IN POTATO UNDER TEMPERATE CONDITIONS

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Abstract: Understanding interrelationships among various agronomic traits is vital to plan an effective breeding program in potato (*Solanum Tuberosum* L.). This study was undertaken in SKUAST-K to determine associations among yield and yield related traits in the crop plant so as to identify the major traits of importance. A replicated field experiment was carried out using thirty eight potato genotypes selected at random from the germplasm collection of diverse origin. Observations were made on five characters. The highest phenotypic and genotypic coefficients of variability were observed for tuber yield on per plot, hectare and plant basis followed by specific gravity, number of stems per hill, number of tubers per plant and plant height. In general the phenotypic coefficients of variation were slight higher than genotypic coefficients of variation for most of the yield contributing characters which indicates the minor role of environment in the expression of these traits. Correlation coefficients revealed that the tuber yield per plant exhibited significant positive association with number of tubers per plant, average tuber weight, plant height, leaf area, plant spread, number of stems per hill, tuber yield per plot /hectare, specific gravity and dry matter. Path coefficient analysis revealed high direct positive effect on tuber yield via number of tubers per plant, tuber yield per plot, average tuber weight, plant height, leaf area and number of stems per hill revealing their importance in the improvement of this crop.

Keywords: Correlation, Solanum tuberosum, Yield

INTRODUCTION

Potato (*Solanum tuberosum* L.) is most important vegetable crop and is widely grown in india. Yield is an important outcome and has an utmost economic importance which a plant breeder always should keep in mind Yield is an ultimate criterion which a plant breeder has always to keep in view in his attempt to evolve improved cultivars of any crop. However, yield is a polygenic character and highly influenced by environment. Knowledge of the association of quantitative characters specifically for yield and its attributes is of immense practical value to obtain an optimal selection index for yield improvement. The selection of one character will lead to indirect change (s) of other character (s) if the two are correlated. Therefore, the knowledge of phenotypic and genotypic correlation and path analysis is important for a plant breeder. Thus the present study was under taken to study the indirect association of various yield components in order to develop a reliable set of traits for indirect selection.

MATERIALS AND METHODS

Material comprised of thirty eight genotypes maintained at SKUAST-K.The genotypes were characterized for various agro-morphological traits. The experiment was laid in RCBD design with four replications during Rabi 2016- 2017. Each replication was divided into eight blocks with eight genotypes per block. The genotypes were planted in three-rowed plots of 2.4 x 1.2 m at a spacing of 60 x 20 cm.Observations were recorded on five randomly selected plants for each entry per replication.Coefficient of correlation was calculated for all possible combinations of all the characters at genotypic, phenotypic and environmental levels by using the following formula proposed by Miller *et al.* (1958).

$$r\ xixj = \frac{Cov\ .xixj}{\sqrt{V(xi)\ V(xj)}}$$

Where, r xixj = coefficient of correlation between characters xi and xj
Cov. xixj = covariance for xi and xj
V (xi) = variance for xi
V (xj) = variance of xj
Genotypic, phenotypic and environmental correlation was computed by substituting corresponding variance and co-variance in the above mentioned formula for all the possible character combinations.
Path coefficient analysis was laid out to show the cause and effect relationship between yield and its components and their partition into direct and indirect effects. This relationship was evolved by Wright (1921) which was later used by Dewey and Lu (1959) and the residual effects were calculated as per procedure given by Singh and Choudhary (1985).

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Unexplained variation of the residual effects was obtained from the equation:

$$R = \sqrt{1 - \Sigma dirij}$$

Where, R = residual effect
di = direct effect of the i^{th} character
rij = correlation coefficient between the i^{th} character and j^{th} dependent character.
Direct and indirect effects of different characters on tuber yield per plant were calculated at both genotypic and phenotypic levels.

RESULTS AND DISCUSSION

The Correlation coefficients were determined using variances and co variances to obtain relationship among various characters and their relationship with tuber yield plant^{-1}.
The correlation coefficients genotypic (r_g) among the various growth characters of potato genotypes/varieties are presented in Table-1. Correlation coefficients revealed that the economically important trait i.e. tuber yield plant^{-1} exhibited significant positive association with number of stems hill^{-1} ($r_{g=}$ 0.4338), plant height ($r_{g=}$ 0.6889), plant spread ($r_{g=}$ 0.4856), leaf area ($r_{g\ =}$ 0.4915), number of tubers plant^{-1}($r_{g=}$ 0.6474), average tuber weight ($r_{g=}$ 0.5976), tuber yield plot^{-1} ($r_{g=}$ 0.8623), tuber yield hectare^{-1} ($r_{g=}$ 0.8973), specific gravity ($r_{g=}$ 0.4126) and dry matter ($r_{g=}$ 0.4724) at genotypic level. The probable reason for leaf area being positively and significantly correlated with tuber yield could be attributed to more amount of photosynthesis occurring. More photosynthesis, as a result, would account for effective conversion of carbohydrates (reserve material) to economic yield by increasing the number or average weight of tubers. Plants with higher number of stems, spread and height could produce more number of leaves which may lead to accumulation of more photosynthates for tuber development resulting in increased tuber weight and finally tuber yield.The positive and significant correlation of yield with dry matter and specific gravity might be due to the reason that, as dry matter and specific gravity go high, the tuber weight is also high and hence the tuber yield is more. Leaf area was positively and significantly associated with plant spread and yield ha^{-1}; plant height had a positive significant relation with per cent emergence days after planting, plant spread, average tuber weight and yield ha^{-1} and dry matter. Similarly, plant spread exhibited positive and significant correlation with, leaf area, plant height, yield ha^{-1} and dry matter. Specific gravity and dry matter showed positive and significant relation, thereby indicating that the change in one character will lead to simultaneous change in the other. The significant and positive association among the characters suggests the scope for improvement of these traits, which may influence each other and in turn may improve the tuber yield.The present findings are in close agreement with the results of Bhagowati *et al.* (2002) between plant height and leaf numbers, tuber numbers and average tuber weight, primary branch numbers and leaf numbers, tuber numbers and between leaf numbers and average tuber weight; Ozkaynak *et al.* (2003) for yield with plant height, number of tubers plant^{-1} and average tuber weight; Luthra *et al.* (2005) for yield with plant height, number of tubers^{-1}, stems hill^{-1}, tuber yield plant^{-1} and tuber weight; Dereje and Basavaraja (2005) for tuber yield with plant spread; Pandey *et al.* (2005) for yield and dry matter content; Rasool *et al.* (2007) for yield with number of tubers plant^{-1}, average weight tuber^{-1} (tuber size), plant height, diameter of main stem and number of main and secondary stems plant^{-1}; Khayatnezhad *et al.* (2011) for tuber yield with number of main stem plant^{-1}, plant tuber weight and plant height; Nasiruddin *et al.* (2014) for tuber yield plant^{-1} with plant height, main stem number plant^{-1}, canopy size, leaf area plant^{-1} and dry matter; Singh *et al.* (2015) for tuber yield hectare^{-1} with marketable tuber yield ha^{-1}, fresh weight of tubers plant^{-1}, number of shoots plant^{-1}, number of tuber plant^{-1} and plant emergence per cent . in general, the estimate of genotypic correlation coefficients of yield and yield attributing characters indicating a strong inherent association between various traits under study and the masking effect of environment in the total expression of genotypes or a strong inherent association between various traits under study. Similar findings have also been reported by Ramanjit *et al.* (2001), Roy and Singh (2006) and Ummyiah *et al.* (2013).
TSS ($r_{g=}$ -0. 2303) and vitamin C ($r_{g=}$ -0.0127) exhibited negative and non-significant association with tuber yield plant^{-1}. Per cent emergence days after planting ($r_{g=}$0.1283) and days taken to flowering ($r_{g=}$0.1222) showed positive but non-significant association with yield plant^{-1}. In addition to this, negative and non significant interrelationship was observed between yield plant^{-1} and vitamin C which was in conformation with the results obtained by Desai and Jaimini (1988) and Ummyiah and Khan (2013). There is a definite metabolic correlation between the content of carbohydrates and the vitamin C present. Every plant requires a specific quantum of energy for performing the metabolic activities for which the energy is provided by carbohydrates and proteins which may be converted to other substrates when the plant system needs it. So, keeping in view the specific amount of energy needed by the plant, the total amount of carbohydrates (i.e. yield) may decrease, if the amount of vitamin C increases. Similar case has been observed in *Brassica* group *(Brassica juncea, Brassica napus* etc.) where a triangular correlation exists between carbohydrates, proteins and oil. If oil content increases, the carbohydrates and proteins automatically decrease.

Table 1. Genotypic correlation coefficients for various yield and quality component traits in potato (*Solanum tuberosum*. L)

S. No.	Parameters	% emergence days after planting	Number of stems hill^{-1}	Days taken to flowering	Plant height (cm)	Plant spread (cm)	Leaf area(cm^2)	Number of tubers plant^{-1}	Average tuber weight(g)	Tuber yield plant^{-1}(g)	Tuber yield plot^{-1}(kg)	Tuber yield hectare^{-1} (q)	Specific gravity	Total soluble solids (^{o}B)	Vitamin C (mg 100g^{-1})	Dry matter (100g^{-1})
1.	Per cent emergence days after planting	-------	- 0.183	0.1953	0.367*	0.2917	0.1318	0.0275	0.2436	0.1283	0.3126	0.4436*	0.2374	0.0366	0.0339	0.3905*
2.	Number of stems hill^{-1}		--------	0.0478	0.271	0.325	0.2658	0.7899**	0.4881**	0.4338**	0.1358	0.2573	0.0775	0.1541	-0.1782	0.3516*
3.	Days taken to flowering			--------	0.1801	-0.1211	-0.0347	-0.2254	0.2276	0.1222	0.1979	0.1381	-0.0727	-0.1039	-0.1973	0.3608
4.	Plant height (cm)				--------	0.3876*	0.2417	0.2859	0.5761**	0.6889**	0.464**	0.6797**	0.2227	0.0482	-0.1791*	0.4698**
5.	Plant spread (cm)					--------	0.5467**	0.3776	0.3409	0.4856**	0.5976**	0.6107**	0.1907	0.2622	-0.2185	0.0236
6.	Leaf area (cm^2)						--------	0.3163	0.2719	0.4915**	0.5399**	0.6476**	0.0658	0.1031	-0.3212	0.5418**
7.	Number of tubers plant^{-1}							--------	0.037	0.6474**	0.6104**	0.7236**	0.1531	0.228	-0.3421*	0.4551*
8.	Average tuber weight (g)								--------	0.5976**	0.555**	0.608**	0.4044*	-0.1773	-0.5779**	0.0184
9.	Tuber yield plant^{-1}(g)									--------	0.8623**	0.8973**	0.4126*	-0.2302	-0.0127	0.4724*
10.	Tuber yield plot^{-1} (kg)										--------	0.7529**	-0.1805	0.2286	-0.4124**	0.5693*
11.	Tuber yield hectare^{-1}(q)											--------	-0.024	0.2791	-0.3898*	0.3681*
12.	Specific gravity												--------	0.2449	0.2847	0.7853**
13	Total soluble solids (^{o}B)													--------	0.1458	0.396*
14.	Vitamin C (mg 100g^{-1})														--------	0.215
15.	Dry matter (100g^{-1})															--------

** significant at 1%, * significant at 5%

The path coefficient analysis (Table 2) revealed that the traits viz., number of stems hill^{-1}, leaf area, plant height, number of tubers plant^{-1} and average tuber weight showed the positive direct effect on tuber yield plant^{-1}. The number of tubers plant^{-1} exerted highest positive direct effect on tuber yield plant^{-1} followed by yield plot^{-1}, average tuber weight, plant height and leaf area whereas, traits like plant spread and yield hectare^{-1} showed negative direct effect on yield plant^{-1}. Significant positive correlation coefficients of number of stems hill^{-1}, plant height, plant spread, leaf area, number of tubers plant^{-1}, average tuber weight and yield ha^{-1}, strengthened their reliability in the process of selection for improvement in tuber yield.

Positive direct effect on tuber yield had been reported by Patel *et al.* (2002) and Sattar *et al.* (2007) for tuber number and average tuber weight; Ara *et al.* (2009) and Lamboro *et al.* (2014) for number of stems; Khayatnezhad *et al.* (2011) for plant height and tuber weight; and Ummyiah *et al.* (2013) for average tuber weight, number of tubers plant^{-1} and plant height.

Negative direct effects on yield plant^{-1} were reported by Dereje and Basavaraja (2005) for plant spread. It is therefore, suggested that the characters which exhibited highest direct effect on tuber yield should be taken into consideration during selection programme for the improvement of yield in potato. Regarding positive indirect effects on tuber yield plant^{-1}, number of stems hill^{-1} exhibited indirect positive effect via, leaf area, plant height, number of tubers plant^{-1}, average tuber weight and tuber yield hectare^{-1}; plant height via number of stems hill^{-1}, leaf area, number of tubers plant^{-1}, average tuber weight and yield hectare^{-1}; leaf area via number of stems hill^{-1}, plant height, plant spread, number of tubers plant^{-1}, average tuber weight and yield hectare^{-1}; plant spread via number of stems hill^{-1}, leaf area, number of tubers plant^{-1}, average tuber weight and yield hectare^{-1}; number of tubers plant^{-1} via number of stems hill^{-1}, plant height, leaf area, average tuber weight and yield ha^{-1}; average tuber weight via number of stems hill^{-1}, plant height, leaf area, number of tubers plant$^{-1,}$ average tuber weight and and yield hectare^{-1} via number of stems hill^{-1}, plant height, leaf area, number of tubers plant$^{-1,}$ and average tuber weight. Indirect positive effects towards tuber yield through various traits were reported by many workers such as Dereje and Basavaraja (2005); Roy and Singh (2006); Sattar *et al.* (2007); Singh (2008); Ummyiah *et al.* (2013); and Singh *et al.* (2015). This suggested that for selecting genotypes with higher yield the indirect influence of different traits should also be given due weightage alongwith characters which exert direct effects.

The estimate of residual effect reflects the adequacy and appropriateness of the characters chosen for path coefficient analysis. In the present investigation the residual effect was low (0.0493) indicating the adequacy of characters chosen for the study and the characters studied contributed significantly towards tuber yield plant^{-1}.

The above discussion brought out that number of stems hill^{-1}, leaf area, plant height, number of tubers plant^{-1}, average tuber weight and yield ha^{-1} are the primary contributors for tuber yield plant^{-1} in potato and plants can be selected directly for these traits for improvement of tuber yield plant^{-1} to evolve better lines and to increase the production of the crop.

Table 2. Genotypic path analysis showing direct (diagonal) and indirect (off diagonal) effects of different yield parameters on yield in potato (*Solanum tuberosum*. L)

S. N.	Parameters	Number of stems hill^{-1}	Plant height (cm)	Plant spread (cm)	Leaf area (cm^2)	Number of tubers plant^{-1}	Average tuber weight (g)	Tuber yield plot^{-1}(kg)	Tuber yield hectare^{-1} (q)	Genotypic correlation with yield plant^{-1}
1.	Number of stems hill^{-1}	0.024	0.078	-0.030	0.031	0.168	0.081	0.024	0.039	0.433*
2.	Plant height (cm)	0.014	0.231	-0.057	0.083	0.058	0.195	0.043	0.069	0.688**
3.	Plant spread (cm)	0.013	-0.107	-0.126	0.089	0.198	0.251	0.081	0.073	0.485**
4.	Leaf area (cm^2)	0.016	0.029	0.051	0.044	0.083	0.149	0.039	0.057	0.491**
5.	Number of tubers plant^{-1}	0.015	0.055	-0.035	0.031	0.346	0.111	0.041	0.063	0.647**
6.	Average tuber weight (g)	0.008	0.183	-0.051	0.030	0.006	0.317	0.039	0.051	0.597**
7.	Tuber yield plot^{-1}(kg)	0.031	0.165	0.012	0.029	0.135	0.228	0.324	0.027	0.862**
8.	Tuber yield hectare^{-1} (q)	0.018	0.182	-0.098	0.045	0.394	0.237	0.151	-0.116	0.897**

** significant at 1%, * significant at 5% Residual effect: 0.0493

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RESEARCH ARTICLE

EFFECT ON GROWTH PARAMETERS AND OIL CONTENT OF LEMONGRASS WITH RESPECT TO IRON PYRITE UNDER AND CONTINUOUS USE OF RSC RICH IRRIGATION WATER

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Abstract. An experiment was conducted at, School of Chemical Sciences Department of Chemistry, St. John's College Agra, in factorial randomized block design by using different concentrations of RSC rich irrigation water (viz, 0, 5, 10 and 15 meq/l) with an aim to know the "oil content and growth characters of lemongrass with respect to iron Pyrite and RSC rich irrigation water". The chemical ameliorant pyrite in lemongrass was applied through basal application @ 0, 5 and 10 t/ha at the time of the transplanting. The results showed that the oil content and growth characters of lemongrass decreased significantly with increasing levels of RSC on the other hand enhancing levels of pyrite significantly increased all the above characters but Pyrite did not show appreciable performance in case of plant height. The P_2 (10 t/ha) level of pyrite proved more beneficial with regards to herbage yield of lemongrass.

Keywords: RSC, Pyrite, Lemongrass, Growth parameters, Oil

INTRODUCTION

The continuous use of rich RSC water for irrigation develops the higher concentration of exchangeable sodium ion on the exchange complex of the soil rendering it unsuitable for cultivation (Kanwar and Kanwar 1971). For neutralizing the adverse effect of various ions of salts in soil, a number of amendments such as Gypsum and Pyrite (Bhadauria and Gupta 2015, Bhadaura et. al 2009, Chauhan et.al 1989, Somani 1984) have suggested. The main objectives of chemical amendment application are to furnish soluble calcium to replace adsorbed sodium form soil colloidal complex. Because of the enhancement in the cost of inputs, the cultivation of traditional crops is becoming uneconomic with the use of rich RSC water. With the point of view of profitable trend in comparison to traditional agriculture, introduction of some new plant type having sodocity tolerances and high benefit cost ratio (B/C ratio) may attract the farmers to continue farming. Therefore, cultivation of high value aromatic plants may be a very good alternative for such problems for increasing the return to the growers as well as foreign exchange to the country. Lemongrass (*Cymbopogon flexuosus*) also is an important aromatic perennial grass and may be grown on warm and humid climate. In India lemongrass oil is primarily used for the isolation of citral for manufacturing vitamin A. Citral is also starting material for the preparation of ionones and it is also used flavor, cosmetic and perfumery industries. A small amount of oil is use as such in soaps, detergent and other preparation. In some countries, the grass is cultivated for flavoring food, such as chicken.

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MATERIALS AND METHODS

A green house experiment was conducted at St. John's College Agra in earthen pots of 30 cm. diameters filled with 10 kg soil, in factorial randomized block design. All twelve treatments were replicated thrice. The soil of the experimental site having sandy loam in texture with pH 7.90, ECe 1.75 dsm^{-1}, Organic carbon 0.12 %, available N 78.0 Kg ha^{-1}, P 16.60 Kg ha^{-1}, K 455.0 Kg ha^{-1}, silt 17.0 and clay 15.4 %. Optimum moisture level was maintained with water with at four levels of RSC viz. 0, 5, 10, & 15 meq/l .The RSC were adjusted by dissolving required amount of sodium bicarbonate ($NaHCO_3$), in distilled water. Distilled water was used to avoid any contaminations of impurities. The 45 days old seedlings of lemongrass were transplanted in pots by using the irrigation and 40 Kg N ha^{-1}, 50 kg P_2O_5 ha^{-1}, 20 kg K_2O ha^{-1} through urea, single super phosphate & muriate of potash in lemongrass respectively. The oil content in fresh herb of lemongrass was estimated by steam distillation process using Clevenger's glass apparatus. The growth observations and herb yield data were recorded at first & second cuttings.

RESULTS AND DISCUSSION

The data obtained on different growth characters are discussed under the following appropriate head

Plant Height and Number of Tillers $Plant^{-1}$:

There was gradual reduction in all the growth parameters studied with the increase in RSC rich water concentration levels at both harvests. However the sodicity in terms of CO_3^{--} and HCO_3^- concentration was found more depressive. It was further recorded that the R_2 and R_3 levels of RSC @ 10 and 15 mel^{-1} of water alkalinity caused reduction in plant height and No. of tillers $plant^{-1}$ followed by R_0 and R_1 levels at both the cuttings of lemongrass. The levels R_0, R_1, R_2 and R_3 showed significant difference with each other at both harvests of lemongrass respectively. This reduction may be ascribed due to development of unfavorable atmosphere around root zone of plants with the use of RSC rich water (Chauhan et. al 1989, Singh and Abrol 1986). The table further showed that the plant height and no. of tillers $plant^{-1}$ increased significantly at both the harvests of lemongrass with pyrite, as compared to control. The P_1 and P_2 levels of lemongrass were found to be superior over other levels at both the cuttings (Bhadauria and Gupta 2015, Chauhan 1987, Prasad et al. 1982, Verma and Gupta 1984). This enhancement may be ascribed due to the physical condition of soil improved, therefore, nutrients supply to the plants increased.

Herb Yield

The herb yield of lemongrass was highest at R_0 level and the minimum yields recorded at R_3 sodocity level (Bhadauria and Gupta 2015, Agarwal et. al 1964). Declined yield could be explained on the basis of deleterious effect of salinity on plant height and no. of tillers. Reduced plant height depressed the crop yield by reducing photosynthesis surface leading to poor synthesis of carbohydrates on one hand and its poor translocation and utilization on the others. An accumulation of alkali salts in soil by one way or the other leads to reduced water absorption from soil through increasing osmotic pressure of soil solution beyond the critical limits and results in to suppression of plant growth and vigor. When osmotic pressure increased, adjustment of plants related to sodic environment are performed rapidly, the physiological motivation leading to ion selectivity may temporarily be replaced by physiological once in order to restore osmotic balance, which is achieved to a considerable extent by restricted uptake of electrolytes under high sodic condition. Osmotic equilibrium between plant and environment is the result of interplay of checks and balances among which limitations to ion uptake plays an important role. The process of nitrification was inhibited in soil at 10% sodium carbonate resulting in narrowing in crop yield (Laura 1973). The specific effect of CO_3^{--} and HCO_3^- ions seemed to inhibit the metabolic process in plants and appeared responsible for reduction in yield (Paliwal et. al 1975). On the other hand increase in herb yield of the crop at both harvests was significant for each level of iron pyrite as compared to control (Bhadauria and Gupta 2015, Bhadaura et. al 2009). The highest herb yield of crop recorded in P_2 (15 $t.ha^{-1}$) was incorporated in the soil.

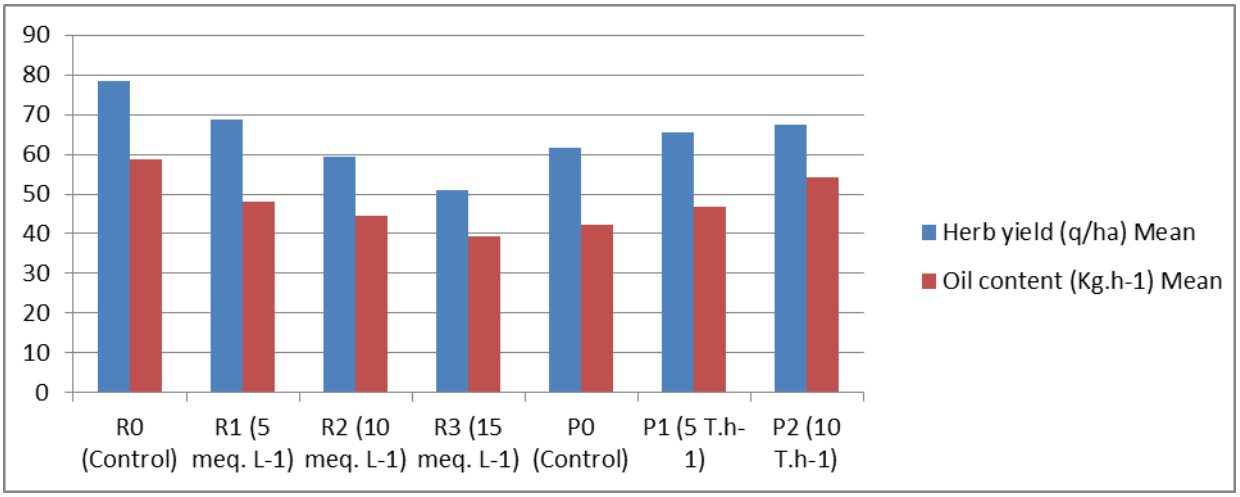
Dry Matter Production

Data with respect to dry matter production at two cuttings as affected by different treatments of sodic water and chemical amendments are equipped in table. It is clear from the results that the dry matter production significantly decreased at two harvests of lemongrass. The R_1 level of sodic water had significant difference (Bhadauria and Gupta 2015, Bhadaura et. al 2009) over R_2 and R_3 levels at both harvests of lemongrass. All levels of RSC water showed highly significant difference with each other. Irrespective of treatment the dry matter production of lemongrass at both harvests may be arranged as $R_0 > R_1 > R_2 > R_3$ respectively pertaining to harmful effect. The reduction in dry matter production due to loss per hectare production of fresh weight, growth phonological characters like no. of tillers and plant height. Therefore low dry matter accumulation under increased level of RSC is quite justified (Chhabra et. al 1980). A further study of table reveals that the dry matter production increased significantly with application of Pyrite at both the harvests of lemongrass respectively. The enhancement in dry matter production is quite obvious as explained with an increment in fresh weight production due to increased availability of nutrients and improvement in physical condition of soil (Bajwa and Jasan 1989, Brar 1987, Singh *et.al*.1986).

Table. Oil content and Growth characters of lemongrass with respect to RSC and Pyrite levels

RSC levels in irrigation Water (meq. L^{-1})	Plant height (cm) Mean	Number of Tillers $Plant^{-1}$ Mean	Herb yield (q/ha) Mean	Dry weight (q/ha) Mean	Oil content ($Kg.h^{-1}$) Mean
R_0 (Control)	94.23	28.27	78.36	27.56	58.84
R_1 (5 meq. L^{-1})	88.54	23.62	68.74	24.42	48.14
R_2 (10 meq. L^{-1})	82.56	19.15	59.21	23.53	44.44
R_3 (15 meq. L^{-1})	72.43	15.54	51.11	21.51	39.39
S.Em ±	0.796	0.587	0.834	0.424	0.753
C.D. at 5 %	2.428	1.685	2.284	1.647	3.254

Pyrite Doses (T.h^{-1})					
P_0 (Control)	83.13	23.43	61.51	23.58	42.16
P_1 (5 T.h^{-1})	85.05	21.42	65.55	24.43	46.75
P_2 (10 T.h^{-1})	87.87	21.12	67.53	26.54	54.20
S.Em ±	0.715	0.507	0.684	0.364	1.121
C.D. at 5 %	2.114	1.453	2.121	1.546	3.102



Oil Content

The data with respect to oil content (kg ha^{-1}) in table clearly stated that the oil content reduced (Bhadaura et. al 2011) significantly with the rising concentration of RSC levels at both the harvests of lemongrass. The reduction in oil content, (Bhadaura et. al 2012 and 2011) was due to the effect of decreased herb yield production of lemongrass crop with the use of RSC rich irrigation water. The level R_3 has resulted marked reduction in oil content in comparison to other RSC levels. The table further indicates that the pyrite application did not reflect its significant effect on the oil content at both harvests of lemongrass. In general the pyrite levels increased the oil content at both two harvests of lemongrass.

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RESEARCH ARTICLE

LIQUID BIO-FERTILIZER FORMULATED FROM COCONUT AND ITS EFFECT ON GROWTH AND ROOT CHARACTERISTICS OF ROBUSTA COFFEE SEEDLINGS UNDER DROUGHT CONDITIONS

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Abstract: A nursery trial was carried out at Regional Coffee Research Station, Chundale, Wayanad district, Kerala during 2018 to study the effects of concentration levels of liquid organic nutrient mixture (20 ml, 30 ml and 40 ml dissolved in 4.5 lit of water square meter of nursery area of area) prepared from coconut, cow byproducts and naturally available organic materials against standard nursery nutrient management practices like application of inorganic fertilizer (20g of urea dissolved in 4.5 lit of water for square meter of nursery area) and supernatant solution of fermented cow dung slurry on growth and root characteristics of robusta coffee seedling. There were significant differences ($p>0.05$) in growth parameters (plant height and numbers of leaves) and root parameters (root length and average root diameter) due to the different nutrient management options. Significant differences were observed in organic treatment resulted in tallest plant height (48.25 cm) and maximum numbers of leaves (16.50) where seedlings received Coconut mixture nutrient spray @ 40 ml and which is on par with the treatment received Coconut mixture nutrient spray @ 30 ml and shortest plant height (31.85 cm) and lesser numbers of leaves (9.15) were noticed in the control without nutrient spray. Similar trend were observed in root parameters and resulted in lengthiest root (39.50 cm) and maximum root diameter (2.45 mm) in the treatment received Coconut mixture nutrient spray @ 40 ml. This preliminary result indicate that liquid organic nutrient mixture prepared from coconut, cow byproducts and naturally available organic materials is an effective bio-fertilizer and are most effective at high levels compared to conventional methods followed by the planters under the moisture stress condition.

Keywords: *Coffea robusta*, Coconut milk extract, Groundnut cake, Organic nutrient mixture

INTRODUCTION

Climate change has become an important area of concern to ensure food and nutritional security for growing population. In the context of climate change and variability, farmers need to adapt quickly to enhance their resilience to increasing threats of climatic variability such as droughts, floods and other extreme climatic events (Mohan Kumar *et al*., 2018). Concentrated efforts are required for mitigation and adaptation to reduce the vulnerability of agriculture to the adverse impacts of climate change and making it more resilient (Chemura *et al*., 2010 & 2013).

The success of new planting in perennial crops like coffee depends primarily on planting of vigorous, disease-free healthy seedlings in the field. Rising of healthy coffee seedlings is an important management practice in coffee plantations due to unreliable rainfalls and frequent droughts that affect growth of seedlings and influence the production of coffee seedlings for new/replanting (Haggar *et al*., 2011). Therefore, utmost attention is required to raise desirable planting material in the nursery (Coffee Guide, 2014).

According to research studies, the coconut milk nutrient mixture made a positive influence on the plant growth and promotes more rapid root formation and ultimately the entire plant especially under stress conditions (Giselle, 2003 and Sandoval *et al*., 2014). Studies on application of coconut nutrient mixture spray on coffee seedling at nursery level had not been attempted in coffee grown region. Hence, keeping in view the above facts, investigation was carried out to study the influence of liquid bio-nutrient mixture on growth and root characteristics of robusta coffee seedlings under drought conditions and to establish the healthy robusta coffee seedlings, which have direct implications to coffee production.

MATERIALS AND METHODS

A nursery experiment was conducted at Regional Coffee Research Station, Chundale, Wayanad

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district, Kerala during 2018 to study the influence of organic nutrient mixer prepared from coconut, banana, groundnut cake and cow milk curd on Robusta coffee seedlings. Wayanad is a conventional coffee growing district of Kerala state and situated at an elevation ranging from 700 mm to 2100 mm above MSL. During the hot weather, the temperature goes to maximum 35^0C and during the cold weather goes down to 7^0C. The average rain fall is 2800 mm per year.

The experiment was laid out with 6 treatment combinations and 3 replications in randomized block design at nursery. The treatment includes planters practices (Urea 20 g and Fermented cow dung slurry @ 30 ml spray) and three levels of coconut mixture nutrient spray (20, 30, 40 ml/4.5 lit water for every square meter of area). Three months aged C x R variety of coffee seedlings was used for this trial. The treatment details are given below,

T1: No nutrient mixture spray - Control
T2: Urea spray @ 20 g (standard practice)
T3: Coconut mixture nutrient spray @ 20 ml
T4: Coconut mixture nutrient spray @ 30 ml
T5: Coconut mixture nutrient spray @ 40 ml
T6: Fermented cow dung slurry @ 30 ml (conventional practice)

Preparation of liquid bio-nutrient mixture

Mix 5 litres of coconut milk and 5 litres of tender coconut water with 1 litre of cow milk curd and add poovan variety of banana (6 nos.), groundnut cake (1kg) and jaggery (1 kg) in to the above mentioned solution. Mix thoroughly and ferment this mixture in a earthen pot for a week to 10 days. Stir this mixture daily both morning and evening stir the mixture in clock and anti clock wise direction. Ensure it is closed tightly with cloth, bury 3/4 of the pot in a pit which is already prepared. The pit has to be filled with organic manner like humus, compost and soil to maintain the optimum heat for fermentation. Filter and mix it with water as the treatments and spray on the coffee seedlings in 2 times at 7 days intervals.

RESULTS AND DISCUSSION

Effect of organic nutrient spray on growth characteristics of Robusta coffee seedlings

Plant height and numbers of leaves

During final observation time, among the treatments, the seedlings received Coconut mixture nutrient spray @ 40 ml showed significant difference with respect to plant height (48.25 cm) and numbers of leaves (16.50) and which is on par with the treatment received Coconut mixture nutrient spray @ 30 ml (47.40 cm and 15.50 respectively). This might be slow and continues supply of nutrients from organics applied to the plants (Da Matta, 2004; Worku and Astatkie, 2010 and Sandoval *et al*., 2014). This is followed by treatment received Coconut mixture nutrient spray @ 20 ml (T3) and Fermented cow dung slurry @ 30 ml. Shortest plant height (31.85 cm) and lesser numbers of leaves (9.15) were noticed in the control without nutrient spray (Table1).

Table 1. Effect of organic nutrient spray on growth characteristics of Robusta coffee seedlings.

Treatments	Plant height (cm)	No. of leaves
T1: No nutrient mixture spray - Control	31.85	9.15
T2: Urea spray @ 20 g (as recommended by the coffee board)	38.50	11.64
T3: Coconut mixture nutrient spray @ 20 ml	43.25	13.61
T4: Coconut mixture nutrient spray @ 30 ml	47.40	15.50
T5: Coconut mixture nutrient spray @ 40 ml	48.25	16.50
T6: Fermented cow dung slurry @ 30 ml	43.00	13.54
SEd	1.19	0.44
CD (5%)	3.41	1.25

Effect of organic nutrient spray on root characteristics of Robusta coffee seedlings

1. Root length:

Among the treatments (Table 2), the seedlings received Coconut mixture nutrient spray @ 40 ml (T5) showed significant difference with respect to root length of seedlings (39.50 cm) and which is on

par with the treatment received Coconut mixture nutrient spray @ 30 ml (T4) (39.20 cm). This is followed by treatment received Coconut mixture nutrient spray @ 20 ml (T3) and Fermented cow dung slurry @ 30 ml (T6). The least length was recorded in the control (T1) (30.12 cm). This result coincides with the research findings of Giselle H. Bui, (2003) and Sandoval *et al*. (2014).

2. Average root diameter:

Among the treatments (Table 2), the seedlings received Coconut mixture nutrient spray @ 40 ml (T5) showed significant difference with respect to root length of seedlings (2.45 mm) and which is on par with the treatment received Coconut mixture nutrient spray @ 30 ml (T4) (2.34 mm). This is followed by treatment received Coconut mixture nutrient spray @ 20 ml (T3) and Fermented cow dung slurry @ 30 ml (T6). The least length was recorded in the control (T1) (30.12 cm). This result coincides with the research findings of Tilak *et al*. (2005) and Chemura *et al*. (2013). The least root diameter was recorded in control (1.45 mm).

Table 2. Effect of organic spray on root characteristics of Robusta coffee seedlings.

Treatments	Root length (cm)	Average root diameter (mm)
T1: No nutrient mixture spray - Control	30.12	1.45
T2: Urea spray @ 20 g (as recommended by the coffee board)	34.39	1.78
T3: Coconut mixture nutrient spray @ 20 ml	37.30	2.10
T4: Coconut mixture nutrient spray @ 30 ml	39.20	2.34
T5: Coconut mixture nutrient spray @ 40 ml	39.50	2.45
T6: Fermented cow dung slurry @ 30 ml	36.19	1.98
SEd	0.43	0.06
CD (5%)	1.23	0.18

CONCLUSION

It is concluded with this Preliminary data that seedlings received Coconut mixture nutrient spray @ 40 ml showed significant difference with respect to growth and root characters and which is on par with the treatment received Coconut mixture nutrient spray @ 30 ml to other treatments compared to the conventional nutrient management practices in nursery. Adoption of such resilient practices and technologies by farmers appears to be more a necessity than an option. This information is important in building a productive, sustainable and robust coffee production system under challenges of environmental accounting and reduced rainfalls in rain-fed systems due to climate change.

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