ISSN 0250-5193

GUJARAT AGRICULTURAL UNIVERSITIES RESEARCH JOURNAL

S.D.Agricultural University
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VOLUME : 42 NUMBER : 1

JANUARY, 2017

GAU RES. J. 42 (1)

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Gujarat Agricultural Universities Research Journal

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Official Publication of

Gujarat Agricultural Universities, Gujarat State

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GAU Research Journal **42** (1) : 1-7 (January 2017)

Combining ability and gene action for pod yield and its agronomic traits in groundnut (*Arachis hypogaea* L.)

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Received : 13 July, 2016

ABSTRACT

Combining ability was studied with 12 parents in line x tester analysis for 12 quantitative characters in order to identify suitable parents/crosses, which could be utilized in *Arachis hypogaea* L. for further improvement programme. The analysis of variance revealed that both GCA and SCA variances were significant for all the characters indicated the importance of both additive and non-additive genetic components in controlling the expression of these traits. Average degree of dominance reflected the predominance of over dominance in these characters expression. Combining ability analysis suggested the preponderance of non-additive as well as additive type of gene action for all these traits. Among the parents, AG-1was the most good general combiners for pod yield and oil content. The cross combinations, AG-1 x ICGV-97079 and AG-2006-6 x ICGV-95070 were identified as potential ones based on their SCA and heterotic effects, which had involved either G x G orG x A general combiners and confirms the validity of average degree of dominance values.

Key words: Additive, combining ability, heterosis, non-additive, pod yield

Groundnut is first ranking oilseed crop of India and it is native of South America. It is a legume that ranks 6th among the oilseed crops and 13thamong the food crops of the world (Groundnut, ICRISAT) and is the world's most important source of edible oil. Among oil seed crops grown in India, groundnut occupies predominant position(Zalate and Padmani, 2009) in area and production. It has now not remained only as an important edible oilseed, but also gained prominence as an important cash crop and foreign exchange earner for India in general and for Gujarat in particular. Therefore, the groundnut is rightly called as "King of oilseeds" in India (Maurya *et al.* 2014). Shalled groundnuts are basically used as seed, consumed as raw edible groundnuts or after transformation into "prepared" groundnuts (roasted, salted, flavored, etc.) or into groundnut butter/paste. It has oil content around 45-50% (Maurya *et al.*, 2014) and extensively used for important source of vegetable oil. At present for the success of groundnut breeding programme, the basic need is selecting proper parents for hybridization. The study of heterosis shows the percentage as increase or decrease of the F_1 over the economic parents or better parents but it fails to identify the possible causes for the superiority of hybrid. The knowledge of combining ability provides a useful clue for selection of desirable parents for the development of better hybrids/genotypes, which are superior in yield, quality and resistance to diseases and pests over the presently cultivated. Thus, information regarding heterosis and combining ability are the basic requirements for a thorough understanding of genetic architecture of pod yield and its components. Keeping these views in mind, the present study was undertaken to obtain the information pertaining to the extent of heterosis and combining ability for 12 characters utilizing a line x tester mating design.

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MATERIALS AND METHODS

The experimental material consists of 9 lines *viz.*,GG-6, AG-1, AG-2240, AG-2245, AG-2006-6, AG-2006-14, AG-2006-15, TAG-24, TG-26 and 3 testers *viz.*,ICGV-95070, ICGV-97079 and Dh-86 of *Arachis hypogaea* L. These parents were crossed in line x

tester fashion during *kharif and* summer 2010-2011. The resulting 27 hybrids along with their parents and three standard check varieties namely GG-7, GJG-9 and TG-37 A were sown during *kharif* 2011in randomized block design with 3 replications at Regional Research Station, Anand Agricultural University, Anand. The parents and their F_1's were sown in single row of 5.0 m keeping a distance of 30 cm between rows and 10 cm between plants. All recommended agronomic practices were adopted. The observations were recorded on 5 randomly selected plants from each lines for 12 characters *viz.*,plant height at maturity (cm), number of mature pods per plant, dry pod yield per plant (g), kernel yield per plant (g), 100 pod weight (g), 100 kernel weight (g), sound mature kernels (%), shelling percentage (%), harvest index (%) and oil content (%)while days to 50 per cent flowering and days to maturity was recorded on plot basis. The mean data were subjected to line x tester analysis and combining ability effects and variances were estimated while, the magnitude of heterosis over better parent, GCA and SCA effects was estimated as:

a) Heterosis over better parent:

$$\text{Heterobeltiosis } (\%) = \frac{\overline{F_1} - \overline{BP}}{\overline{BP}} \times 100$$

b) GCA Effects: $\hat{g}_i = \frac{Y_{i..}}{rl} - \frac{Y_{...}}{rlt}$ for lines

$$\hat{g}_j = \frac{Y_{.j.}}{rt} - \frac{Y_{...}}{rlt} \text{ for testers}$$

c) SCA Effects : $\hat{s}_{ij} = \frac{Y_{ij.}}{r} - \frac{Y_{i..}}{rl} - \frac{Y_{.j.}}{rt} + \frac{Y_{...}}{rlt}$

Where,

$\hat{g}_i$ = Estimate of general combining ability effect of i^{th} lines parent (i = 1, 2 ...,l number of lines)

$\hat{g}_j$ = Estimate of general combining ability effect of j^{th} testers parent (j = 1, 2 ...,t number of testers)

$\hat{s}_{ij}$ = Estimate of specific combining ability effect of ij^{th} cross combination

$Y_{...}$ = Total of all hybrids in all replications

$Y_{i..}$ = Total of i^{th} lines over all testers and replications

$Y_{.j.}$ = Total of j^{th} testers over all lines and replications

$Y_{ij.}$ = Total of ij^{th} cross combination over all replications

RESULTS AND DISCUSSION

The analysis of variance for combining ability revealed that the variance due to lines revealed significant differences among all the characters while variance due to testers showed significant differences for all the characters except days to 50% flowering, days to maturity and sound mature kernels. The variance due to interaction effect of lines and testers were significant for all the characters reflected the importance of non-additive gene action in the inheritance of these traits. The estimates of variance due to both general combining ability and specific combining ability variance were found to be significant for all characters indicated the involvement of additive and non-additive gene effects for genetic control of these characters (Ahuja and Dhayal, 2007). However, the ratio (GCA/SCA) indicated preponderance of additive gene action for plant height at maturity, 100 pod weight, 100 kernel weight, shelling percentage and oil content whereas, non-additive gene action for days to 50% flowering, days to maturity, number of mature pods per plant, pod yield per plant, kernel yield per plant, sound mature kernels and harvest index, respectively.

Estimates of general and specific combining ability

The estimates of GCA effects (Table 1) were ranged from 5.04 to - 4.07 per cent for days to 50 per cent flowering; 2.00 to -3.00per cent for days to maturity;14.92 to -16.80cm for plant height at maturity;- 6.59 to 5.09 for number of mature pods per plant; - 6.63 to 1.26 g for pod yield per plant;- 4.46 to 1.22 g for kernel yield per plant ;-16.10 to 22.19 g for 100 pod weight;- 4.87 to 7.34 g for 100 kernel weight;- 1.37 to 1.52 % for sound mature kernels;-10.97 to 5.13 % for shelling percentage;-1.61 to 1.74% for harvest index and -4.42 to 2.89 % for oil content. For pod yield per plant, 10 parents had positive GCA effects. Among these, 06 parents (Five line i.e. AG-1, AG-2245, AG-2006-6, AG-2006-15 and TG-26 and only tester i.e. ICGV-95070) had significant GCA effects in desirable direction indicated good general combiners. Six parents were found good general combiners for kernel yield per plant. The parents ICGC-95070, and AG - 2006-15 were found best combiner for pod and kernel yield per plant, whereas genotypes TAG-24 was best general combiners for oil content. However, for the characters*viz.*, days to 50% flowering (06), days to maturity (01), plant height at maturity (05), number of mature pods per plant (05), kernel yield per plant (06), 100 pod weight (03), 100 kernel weight (04),

Table 1 General combining ability effects

Particulars	Days to 50 % flowering	Days to maturity	Plant height at maturity	Number of mature pods per plant	Pod yield per plant	Kernel yield per plant	100 pod weight	100 kernel weight	Sound mature kernels	Shelling %	Harvest index	Oil content
Lines												
GG-6	4.04**	2.00**	-16.80**	-6.59**	-6.63**	-4.46**	-16.10**	-4.87**	-0.59	-7.19**	-1.61**	-4.42**
AG-1	-0.85*	-1.22	7.98**	2.42**	1.19**	1.20**	-3.82*	-3.78**	0.63	4.16**	1.74**	0.72*
AG-2240	1.26**	1.11	8.55**	3.00**	0.58	0.79**	-9.07**	-0.18	1.52**	3.89**	-0.16	1.37**
AG-2245	-4.07**	-1.11	13.96**	0.18	0.67*	1.04**	0.93	-4.28**	0.30	5.13**	1.06*	1.02**
AG-2006-6	5.04**	1.67*	-8.88**	-2.67**	1.21**	-0.84**	20.85**	7.34**	-0.81	-10.97**	1.05*	1.45**
AG-2006-14	2.15**	0.33	0.34	-2.67**	0.47	0.52*	22.19**	5.68**	0.85*	2.17**	-1.55**	-1.19**
AG-2006-15	-2.19**	0.89	14.92**	0.87*	1.09**	1.22**	-0.84	-0.50	-1.37**	4.49**	0.42	0.18
TAG-24	-2.74**	-3.00**	-3.56**	0.36	0.31	0.32	-0.21	2.61**	-1.04*	1.34	-0.08	2.89**
TG-26	-2.63**	-0.67	-16.54**	5.09**	1.11**	0.21	-13.94**	-2.03**	0.52	-3.03**	-0.88	-2.00**
S.E. (Lines)	0.39	0.71	0.98	0.43	0.33	0.23	1.69	0.61	0.42	0.79	0.52	0.31
Testers												
ICGV-95070	0.33	-0.48	2.71**	0.82**	1.26**	0.87**	5.07**	-0.70*	-0.22	1.31**	-0.36	0.60**
ICGV-97079	0.07	0.78*	1.46**	0.34	0.14	0.14	-1.29	1.24**	-0.04	0.23	-0.63*	-0.03
Dh-86	-0.41*	-0.30	-4.16**	-1.15**	-1.40**	-1.00**	-3.78**	-0.55	0.26	-1.54**	-0.99**	-0.54**
S. E. (Testers)	0.20	0.35	0.49	0.21	0.16	0.11	0.85	0.30	0.21	0.39	0.26	0.15
Range: Min.	-4.07	-3.00	-16.80	-6.59	-6.63	-4.46	-16.10	-4.87	-1.37	-10.97	-1.61	-4.42
Max.	5.04	2.00	14.92	5.09	1.26	1.22	22.19	7.34	1.52	5.13	1.74	2.89
Positive	06	06	07	08	10	09	04	04	06	08	04	07
Positive Significant	04	06	06	05	06	06	03	04	02	06	03	06
Negative	06	06	05	04	02	03	08	08	06	04	08	05
Negative Significant	06	01	05	04	02	03	05	05	02	04	04	04

* and ** indicates significant at 0.05 and 0.01 level of probability, respectively

Table 2 Significant GCA effects of parents with desirable direction

Sr. No.	Character	Parent	Significant and desired GCA effects
1	Days to 50% flowering	AG-1	-0.85*
		AG-2245	-4.07**
		AG-2006-15	-2.19**
		TAG-24	-2.74**
		TG-26	-2.63**
		Dh-86	-0.41*
2	Days to maturity	TAG-24	-3.00**
3	Plant height at maturity	GG-6	-16.80**
		AG-2006-6	-8.88**
		TAG-24	-3.56**
		TG-26	-16.54**
		Dh-86	-4.16**
4	Number of mature pods per plant	AG-1	2.42**
		AG-2240	3.00**
		AG-2006-15	0.87*
		TG-26	5.09**
		ICGV-95070	0.82**
5	Kernel yield per plant	AG-1	1.20**
		AG-2240	0.79**
		AG-2245	1.40**
		AG-2006-14	0.52*
		AG-2006-15	1.22**
		ICGV-95070	0.87**
6	100 pod weight	AG-2006-6	20.85**
		AG-2006-14	22.19**
		ICGV-95070	5.07**
7	100 kernel weight	AG-2006-6	7.34**
		AG-2006-14	5.68**
		TAG-24	2.61**
		ICGV-97079	1.24**
8	Sound mature kernels	AG-2240	1.52**
		AG-2006-14	0.85*
9	Shelling %	AG-1	4.16**
		AG-2240	3.89**
		AG-2245	5.13**
		AG-2006-14	2.17**
		AG-2006-15	4.49**
		ICGV-95070	1.31**
10	Harvest index	AG-1	1.74**
		AG-2245	1.06*
		AG-2006-6	1.05*
11	Oil content	AG-1	0.72*
		AG-2240	1.37**
		AG-2245	1.02**
		AG-2006-6	1.45**
		TAG-24	2.89**
		ICGV-95070	0.60**

Table 3 General combining effects of parents in groundnut

Characters	Parents	Per se performance	GCA effects
Days to 50% flowering	AG-2006-14	26.00	2.15**
	TAG-24	26.00	-2.74**
Days to maturity	TAG-24	117.00	-3.00**
	GG-6	117.33	2.00**
Plant height at maturity	TG-26	26.67	-16.54**
	Dh-86	28.00	-4.16**
Number of mature pods per plant	TG-26	25.47	5.09**
	Dh-86	18.63	-1.15**
Pod yield per plant	TG-26	18.20	1.11**
	AG-2006-15	16.92	1.09**
Kernel yield per plant	AG-2006-15	10.49	1.22**
	AG-2006-14	10.19	0.52*
100 pod weight	ICGV-97079	137.74	-1.29
	AG-2006-6	99.52	20.85**
100 kernel weight	ICGV-97079	53.96	1.24**
	AG-2006-6	49.80	7.34**
Sound mature kernels	ICGV-95070	93.33	-0.22
	TAG-24	92.33	-1.04*
Shelling percentage	AG-1	65.23	4.16**
	AG-2240	64.67	3.89**
Harvest index	AG-2245	38.16	1.06*
	AG-2006-14	36.48	-1.55**
Oil content	ICGV-95070	52.70	0.60**
	Dh-86	52.63	-0.54**

sound mature kernels (02), Shelling percentage (06), harvest index (03) and oil content (06) parents manifested GCA effects significant with desirable direction (Table 2.), respectively. The superior parents results into superior hybrids. Hence, these parents may therefore be used in crop breeding programme to improve different traits.

The results revealed that the most of the parents had high degree of correspondence between *per se* performance and their GCA effects for most of the characters, which showed additivity of genes (Table 3). Therefore, in selection of parents for varietal development programme due weightage should be given to *per se* performance along with their GCA effects. This findings are in confirmation with the findings of Nadaf *et al.* 1988, Dwivedi *et al.* 1989, Bansal *et al.* 1991, Upadhyay *et al.* 1992, Anderson *et al.* 1993, Ali *et al.* 1995 and Dobaria *et al.* 2004.

In general, the F_1's which had higher estimates of HB (Heterobeltiosis) for pod yield per plant also had positive heterotic effects with number of mature pods per plant, kernel yield per plant and harvest index while had negative heterotic effects with days to maturity (Table 4). The estimates of specific combining ability effect (Table 4) by and large provide information on role of intra and interallelic interactions in the expression of heterosis and inheritance of a character. Best cross combinations revealed the high SCA effect of F_1's in general corresponded to their high heterotic response, but this may also be accompanied by poor and/or average GCA effect of the parents. This may be due to the presence of genetic diversity in the form of dispersed genes for these characters. It revealed that good x good type of combinations not necessarily results into high SCA effects. This is probably due to internal cancellation of gene effects in these parents.

Table 4 Superior cross combination based on SCA effects in groundnut

Characters	Crosses	Per se performance	Heterosis over better parent	SCA effects	GCA effects
Days to 50% flowering	AG-2245 x ICGV-95070	25.33	-5.00	-1.89**	G x A
	TG-26 x ICGV-95070	25.33	-5.00	-3.33**	G x A
	AG-1 x ICGV-95070	26.00	-2.50	-4.44**	G x A
Days to maturity	TAG-24 x Dh-86	116.67	-0.28	-1.70	G x A
	TAG-24 x ICGV-95070	117.67	0.57	-0.52	G x A
	AG-1 x ICGV-95070	119.33	1.70	-0.63	A x A
Plant height at maturity	TG-26 x ICGV-97079	27.67	3.75	-3.66**	G x P
	GG-6 x Dh-86	28.53	1.90	3.10*	G x G
	TG-26 x Dh-86	29.27	9.75	3.56**	G x G
Number of mature pods per plant	AG-2240 x ICGV-95070	27.40	76.39**	6.74**	G x G
	AG-1 x ICGV-97079	25.87	89.27**	6.26**	G x A
	TG-26 x ICGV-95070	24.40	-4.19	1.65**	G x G
Pod yield per plant	AG-1 x ICGV-97079	19.87	27.81**	5.86**	G x A
	AG-2006-6 x ICGV-95070	17.81	35.38**	2.65**	G x G
	AG-2245 x ICGV-95070	17.64	35.74**	3.02**	G x G
Kernel yield per plant	AG-1 x ICGV-97079	12.77	33.71**	3.81**	G x A
	AG-2245 x ICGV-95070	11.54	44.03**	2.00**	G x G
	AG-2240 x ICGV-95070	10.74	34.08**	1.45**	G x G
100 pod weight	AG-2006-6 x ICGV-95070	108.33	8.86	7.21**	G x G
	AG-2006-14 x ICGV-95070	107.87	23.55**	5.41*	G x G
	AG-2006-14 x ICGV-97079	97.41	-29.28**	1.32	G x A
100 kernel weight	AG-2006-6 x ICGV-97079	47.99	-11.06**	2.34**	G x G
	AG-2006-6 x ICGV-95070	44.79	-10.06**	1.08	G x P
	AG-2006-14 x ICGV-97079	43.90	-18.64**	-0.09	G x G
Sound mature kernels	AG-2240 x ICGV-95070	94.00	0.71	0.89	G x A
	AG-2006-14 x ICGV-97079	94.00	1.81	1.37*	G x A
	AG-1 x Dh-86	93.67	1.81	0.96	A x A
Shelling percentage	AG-1 x ICGV-95070	66.41	1.80	1.23	G x G
	AG-2245 x ICGV-97079	66.37	8.13*	1.29	G x A
	AG-2245 x ICGV-95070	65.24	5.70	-0.92	G x G
Harvest index	AG-1 x Dh-86	38.99	8.12	1.79*	G x G
	AG-1 x ICGV-97079	38.74	10.30*	3.17**	G x P
	AG-2006-6 x ICGV-97079	38.51	11.71**	3.63**	G x P
Oil content	TAG-24 x ICGV-97079	53.06	1.10	0.51	G x A
	AG-2245 x ICGV-95070	53.03	0.63	1.73**	G x G
	TAG-24 x Dh-86	53.01	0.72	1.02*	G x P

Some of the crosses showed significant SCA effects, which had the combination of good x good and good x average GCA effects for pod yield per plant, number of mature pods per plant and kernel yield per plant may be explained because of the main role of the additive gene action. Good x good general combiners showed additive x additive gene action for many characters and its possibility of fixation, single plant selection could be practiced in further segregating generations to isolate superior pure lines from such combinations.The data indicate that none of the hybrids showed consistent SCA effects for all the traits under study. The cross AG-1 x ICGV-97079 and AG-2006-6 x ICGV-95070 recorded the more pod yield, kernel yield, number of mature pod, 100 pod weight and 100 kernel weight. This cross also showed significant heterobeltiosis, SCA effects and both the parents involved were mostly good general combiners.

On the basis of *per se* performance, heterotic response, combining ability estimates, nature of gene action for pod yield and its agronomic traits, AG-1 x ICGV-97079 was found superior and may be used as transgressive segregants in later generations to utilize both the types of gene actions and exploited commercially after critical evaluation for its superiority and stability across the locations and over years.

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GAU Research Journal **42** (1) : 8-12 (January 2017)

Fertility status of cultivated soils in Gandhinagar district of Gujarat

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Received : 30 December, 2016

ABSTRACT

An investigation was carried out to study the fertility status of cultivated soils in Gandhinagar district of Gujarat. The soils of Gandhinagar district are neutral to alkaline in reaction (pH 6.80 to 8.95) having electrical conductivity value varied from 0.094 to 1.897 dSm^{-1}. The data on nutrient status showed that soils are low in organic carbon, medium in available phosphorus, medium to high status of potash and high status of sulphur. Among the DTPA extractable micronutrients, high to very high amount of manganese and copper, whereas marginal status of iron and zinc in soils. The availability of potash, sulphur and DTPA extractable micronutrients (Zn and Cu) were significantly and positively correlated with organic carbon content of soils.

Key word: Fertility, soil properties, micronutrients

At present the exploitive agriculture with sustained efforts to increase crop yield has not only depleted our soils of their nutrient serve, but also resulted in the emergence of a number of new nutrient deficiency in the soils. Optimum use of fertilizers contributes significantly in bringing about an increase in agricultural production. Amount of fertilizers required for same crop varies from soil to soil and even from field to field. Maintenance of fertility of soils is immense concern to obtain harness higher yields (Gupta 2000). Now a day, due to change in cropping pattern and diversification of crops, it is necessary to know fertility status of soils. In the current concept of sustainable agriculture, there is need to understand the characteristics and inherent fertility of the soils for enhancing its productivity. Knowledge about the fertility status of the soils is of prime importance for the optimum use of land. Proper understanding of nutrients availability in soils and extent of their deficiencies is prerequisite for efficient management of fertilizers to sustain the crop productivity. Scantly information is available regarding fertility status of soils and their relationship with soil properties of Gandhinagar district. Therefore, the attempt was made to study the fertility status in soils of Gandhinagar district of Gujarat

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MATERIALS AND METHODS

The study area is located (Gandhinagar district) is located in the Gujarat at 23.01º to 23.56º N Latitude and N 72.33º to E 73.73º E longitude. The district has semi-arid climate and received average rainfall of 667 mm. The main crops grown include castor, cotton, tobacco, rice, pearlmillet, potato, vegetables, mustard, cumin, wheat etc. One hundred seventy seven (177) surface (0-15 cm) soil samples of farmers' field were collected from four talukas (Mansa, Kalol, Gandhinagar, and Dehgam) of Gandhinagar district by following the random sampling techniques. The soil samples, after air drying were ground with wooden mortar and pestle and passed through 2.0 mm sieve. The soil reaction (pH) and electrical conductivity (EC) were determined as per the procedure described by Jackson (1973). The soil organic carbon (OC) was estimated by wet digestion method of Walkley and Black (1934). The available P was extracted by employing Olsen extractant (0.5 M $NaHCO_3$) as described by Olsen *et al.*,(1954) and the available K was extracted by using neutral normal ammonium acetate and the content was determined by aspiring the extract in to flame photometer (Jackson, 1973). The available sulphur in the soil was extracted by 0.15 % $CaCl_2$. $2H_2O$ solution as described by Williums and Steinbergs (1959) and the content of DTPA

Extractable micronutrients *viz.*, Iron (Fe), Manganese (Mn), Zinc (Zn) and copper (Cu) in soil was estimated using 1:2 soil to extractants ratio (Lindsay and Norvell, 1978). Simple correlations were worked out among different chemical properties of soil by standard statistical methods (Panse and Sukhatme, 1967). The nutrient index (NI) values for available nutrients were calculated utilizing the formula suggested by Parkar *et al.* (1951).

$$NI = [(N_l x1) + (N_m x2) + (N_h x3)] / N_t$$

Where, N_l, N_m and N_h are the number of soils samples falling in low medium and high categories for nutrient status and are given weightage of 1, 2 and 3, respectively. N_t is the total number of samples,

The nutrient index value are rated in various categories *viz.*, very low(< 1.33), low (1.33- 1.66) , marginal (1.66 to 2.00), adequate (2.00- 2.33), high (2.33-2.66) and very high (> 2.66) as rating given by Stalin *et al.* (2010).

RESULTS AND DISCUSSION

The chemical properties of soil revealed that the soils of Gandhinagar district are neutral to alkaline in reaction with the pH ranging from 6.80 to 8.95 (Table 1). The highest value of pH was found in Kalol taluka (8.95). As far as electrical conductivity is concerned, the overall value of EC in soils of Gandhinagar district ranged from 0.094 to 1.897 dSm^{-1} with a mean value of 0.522 dSm^{-1}. The higher EC range was observed in kalol taluka. Similar results were found by Thakor *et al.* (2014a) in north Gujarat.

The organic carbon content of soil ranged from 0.123 to 0.765 with a mean value of 0.370 % which indicates poor fertility of soil in Gandhinagar district. This could be ascribed due to rapid decomposition and mineralization organic matter in semi arid climatic conditions. The lowest value of organic carbon content of 0.123 per cent was recorded in soil samples collected from Gandhinagar taluka, whereas the highest value of 0.765 per cent was obtained in Dehgam taluka (Table 1). The mean value of organic carbon content in soil for Mansa, Kalol, Gandhinagar, and Dehgam talukas were 0.406, 0.421, 0.425 and 0.416 per cent, respectively. The lower value of organic carbon in north Gujarat was also reported by Thakor *et. al.* (2014a)

The available P_2O_5 content of soil samples of Gandhinagar district varied between 16.98 to 86.59 kg /ha. The overall mean value of available phosphorus (39.10 kg P_2O_5/ha) also indicate that the soil of Gandhinagar district was medium in available phosphorus status. Similar results were also reported by Thakor *et. al.* (2014a) in Gujarat. The farmers are using only Dia Ammonium Phosphate (DAP) as a source of nutrients in adequate quantity, As a result, available P_2O_5 in medium range. The average available K_2O content of soil varied from 114 to 648 kg/ha with a mean value of 319 kg/ha. (Table 1). High amount of available K in this soil attributed to the prevalence of potassium rich mineral like illite and feldspar. This clearly shows that the soil of Gandhinagar district is medium to well supplied with available potassium. The results are conformity with Hasan (2002).

The available sulphur in soils of Gandhinagar district ranged from 5.42 to 75.25 mg/kg with a mean value of 24.32 mg/kg (Table 1). Considering the 10 mg/kg as critical limit for available sulphur, the soils of Gandhinagar district are adequate in sulphur. The higher concentration of available S in sub tropical region might be attributed to higher amount of soluble salts in these soils. Similar results were reported by Kour and Jalai (2008)

The available Fe content of soil sample varied from 3.34 to 24.08 with a mean value of 6.91 mg/kg (Table 2). The highest mean value was found in Dehgam taluka (7.62 mg/kg) and lowest mean value was found in Mansa taluka (6.38 mg/kg). The DTPA-extractable Zn content in soil ranged from 0.16 to 1.76 mg/kg with a mean value of 0.63 mg/kg (Table 2). Similar Results are also reported by Patel *et. al.* (1998) and Thakor *et. al.* (2014b). The medium status of Fe and Zn might be due precipitation of this nutrients under alkaline condition of soil. The average available Mn content of soil ranged from 3.28 to 23.70 mg/kg with a mean value of 12.93 mg/kg. The average available Cu content of soil ranged from 0.36 to 1.90 with a mean value of 0.96 mg/kg. The higher overall mean values of available Mn and Cu indicates sufficient availability of Mn and Cu in the soils of Gandhinagar district. Similar Results are also reported by Patel *et. al.* (1998) and Thakor *et. al.* (2014b)

Interrelationship among different chemical properties of soil

The correlation coefficient (r) among different chemical properties of soils in Gandhinagar district is presented in Table 3. The available K_2O, S and DTPA-Zn of the soil were found to be correlated positively and significantly with electrical conductivity. Similar relationship was also reported by Chatopadhyay *et al.* (1996). Soil available potassium, sulphur and

micronutrient (Zn, Cu) had significant and positive correlation with organic carbon. The positive correlation between these nutrients and organic carbon content of soil indicate that the availability of nutrients increased with an increase of organic carbon in the soil. Similar relationship was also observed by Dhane and Shukla (1995) and Bhogal *et al.* (1993). Soil available phosphorus showed significant and positive correlation with available K_2O and DTPA Zn.

Nutrient Index Values and fertility status

The nutrient index values (Table 4)for all the nutrients were worked out for all the talukas of Gandhinagar district. The nutrient index value for available phosphorus was ranged from 1.87 to 2.07 indicating marginal to adequate status of phosphorus in soil. The nutrient index values for available potassium ranged from 2.14 to 2.77 indicating adequate to very high status of potassium in soils of Gandhinagar district. The nutrient index value for available sulphur was ranged from 2.11 to 2.40 indicating adequate to high status of sulphur in soil. The nutrient index for Fe ranged from 1.77 to 1.98 indicating marginal status of Fe in soils. The nutrient index for Zn ranged from 1.63 to 1.86 indicating low to marginal status of zinc in soils. The higher nutrient index values were noticed in all the talukas for Mn (2.49 to 2.72) and Cu (2.96 to 3.00) indicating high to very high status of Mn and Cu in soils of Gandhinagar district

Table 1 Chemical characteristics and nutrient status of soils of Gandhinagar district

Taluka	No. of Samples	$pH_{2.5}$	$EC_{2.5}$ (dSm^{-1})	Organic Carbon (%)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)	Available Sulphur (mg/kg)
Mansa	40	7.45-8.75 (8.10)	0.108-1.125 (0.454)	0.265-0.565 (0.406)	22.97-86.59 (37.34)	114-618 (313)	7.41-45.92 (24.64)
Kalol	47	7.00-8.95 (8.29)	0.263-1.897 (0.737)	0.195-0.571 (0.421)	20.78-48.09 (33.94)	195-648 (396)	6.29-51.10 (27.26)
Gandhinagar	47	7.20-8.75 (7.90)	0.266-1.325 (0.525)	0.123-0.493 (0.425)	18.01-80.90 (41.39)	126-640 (315)	7.23-58.87 (20.19)
Dehgam	43	6.80-8.70 (7.47)	0.094-1.562 (0.347)	0.129-0.765 (0.416)	16.98-70.75 (43.5)	118-632 (247)	5.42-75.25 (25.31)
District...	177	6.80-8.95 (7.95)	0.094-1.897 (0.522)	0.123-0.765 (0.37)	16.98-86.59 (39.1)	114-648 (319)	5.42-75.25 (24.32)

Note: Value in parenthesis shows mean

Table 2: Micronutrient status of soils of Gandhinagar district

Taluka	No. of Samples	DTPA –extractable micronutrient (mg/kg)			
		Fe	Mn	Zn	Cu
Mansa	40	4.42-11.10 (6.38)	4.82-23.70 (13.69)	0.30-1.14 (0.59)	0.38-1.26 (0.81)
Kalol	47	3.34-20.20 (6.79)	3.28-20.84 (11.83)	0.28-1.30 (0.63)	0.50-1.90 (0.98)
Gandhinagar	47	3.44-14.10 (6.84)	4.94-21.70 (12.72)	0.36-1.12 (0.58)	0.36-1.34 (0.91)
Dehgam	43	3.88-24.08 (7.62)	4.38-21.62 (13.64)	0.16-1.76 (0.74)	0.46-1.72 (1.15)
District...	177	3.34-24.08 (6.91)	3.28-23.70 (12.93)	0.16-1.76 (0.63)	0.36-1.90 (0.96)

Note: Value in parenthesis shows mean

Table 3 Correlation coefficient (r) between different chemical properties of soil

Soil Properties	EC_{25}	pH_{25}	Org. Carbon (%)	Ava. P_2O_5 (kg/ha)	Ava. K_2O (kg/ha)	Ava. S (mg/kg)	DTPA –extractable micronutrient (mg/kg)		
							Fe	Mn	Zn
pH_{25}	0.341**								
Org. Carbon(%)	0.131	0.077							
Avail. P_2O_5 (kg/ha)	0.039	-0.116	0.033						
Avail. K_2O (kg/ha)	0.267**	0.166*	0.171*	0.209**					
Avail. S (mg/kg)	0.350**	-0.020	0.317**	-0.037	0.135				
Fe (mg/kg)	0.020	-0.001	0.001	0.115	0.088	-0.001			
Mn (mg/kg)	0.031	-0.283**	0.069	-0.009	0.046	0.059	-0.184*		
Zn (mg/kg)	0.177*	0.018	0.221**	0.201**	0.168*	0.156*	0.338**	0.142	
Cu (mg/kg)	0.105	-0.199**	0.175*	0.132	0.098	0.233**	0.275**	0.142	0.250**

Table 4: Nutrient index values of available nutrients in soils of Gandhinagar district

Taluka	Available P_2O_5	Available K_2O	Available S	DTPA Extractable Micronutrients			
				Fe	Mn	Zn	Cu
Mansa	1.98	2.43	2.40	1.85	2.68	1.63	2.98
Kalol	1.87	2.77	2.40	1.79	2.49	1.77	3.00
Gandhinagar	1.87	2.40	2.11	1.98	2.64	1.64	2.96
Dehgam	2.07	2.14	2.33	1.77	2.72	1.86	3.00
District	1.94	2.44	2.31	1.82	2.63	1.76	2.98

CONCLUSION

The results of study indicate that soils of Gandhinagar district are neutral to alkaline in reaction with low in organic carbon. The soils of Gandhinagar district are low to medium in available P_2O_5 ; high in available K_2O and sulphur content. With respect to DTPA Mn and Cu, these soils were found to be sufficient but for DTPA Zn and Fe, it was medium in status. This information can be useful for the cultivated soils of Gandhinagar district.

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GAU Research Journal 42 (1) : 13-20 (January 2017)

Status of pink bollworm, *Pectinophora gossypiella* (Saunders) infesting *Bt* cotton under middle Gujarat conditions

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Received : 2 November, 2016

ABSTRACT

Field studies were conducted to know the status of pink bollworm infesting *Bt* cotton in two districts (Kheda and Vadodara) of Gujarat. The higher damage due to *Pectinophora gossypiella* (Saunders) was recorded in Karjan taluka of Vadodara district during the years 2014-15 and 2015-16. During 2014-15, the per cent infestation due to pink bollworm was found 26.29 and 5.52 in Kheda and Vadodara district, respectively. Similarly, per cent infestation caused by this pest was observed 31.10 and 15.28 in Kheda and Vadodara districts, respectively during 2015-16. The incidence of *P. gossypiella* was higher during 2015-16 as compared to 2014-15 in middle Gujarat.
and positively correlated with organic carbon content of soils.

Key word: Pink bollworm, *Bt* cotton,

Bt cotton is widely accepted by the cotton growers of India and Gujarat as well. In India, cotton crop cultivated about 118.81 lac hectares with the production of 352.00 lac bales, whereas in Gujarat, it was cultivated 27.61 Lac hectares with the production of 101.00 Lac bales during the year 2015-16 (http:// cotcorp.gov.in). In India, bollworms commonly encountered in cotton cultivation are spotted bollworm, *Earias vittella* (Fabricius), American bollworm, *Helicoverpa armigera* (Hubner) Hardwick, Tobacco leaf eating caterpillar, *Spodoptera litura* (Fabricius) and pink bollworm, *Pectinophora gossypiella* (Saunders). On introduction of *Bt* cotton, bollworms remained under control. However, pink bollworm showed increasing trend in *Bt* cotton. It has now become a most serious pest of *Bt* cotton in Gujarat since last two years causing losses in both yield and quality of cotton. During recent past, it has emerged as a threat to cotton growing areas of India. It causes loculi damage to an extent of 55 per cent and reduction in seed cotton yield in the range of 35-90 per cent. The losses due to this pest was estimated to the tune of 6525 metric tonnes of lint worth Rs.1216 million (Agarwal and Katiyar, 1979). World over, pink bollworm, *P. gossypiella* is the most destructive pest of cotton and is known to cause 2.8 to 61.9 per cent loss in seed cotton yield, 2.1 to 47.1 per cent loss in oil content and 10.7 to 59.2 per cent loss in normal opening of bolls (Patil, 2003). The destructive larvae usually feed on flower buds, bolls and seeds therein, which results in malformation, rotting, premature or partial boll opening, reduction in fibre length and overall reduced quality of the cotton due to staining of lint. The larval stage is usually buried within the cotton fruiting bodies making them inaccessible to insecticidal sprays owing to which its management is somewhat difficult. Pink bollworm management on cotton was thought to be tough because the larval stages were spent within the cotton bolls. Eggs are laid under the bracteoles, at the base of the boll and flowers particularly on green bolls. On hatching, larvae penetrate flowers or bolls within 20 min (Hutchison *et al.*, 1988) to 2h (Ingram, 1994). Therefore, conventional methods including insecticidal applications are difficult to manage the pest. It has also developed resistance to Cry I Ac as reported by Sharma (2009).

Ignorance of structured refugea strategy, raising of long term events, improper disposal of cotton sticks, limited natural enemies, changed schedule of insecticidal spray, development of resistance, hidden nature of the pest *etc.* are responsible for the unusual attack of pink bollworm even in BG-II.

The report of ineffectiveness of Bollgard (Cry I Ac) to pink bollworm in certain parts of Gujarat (The

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Hindu, Dated 6.3.2010) has compelled to study the pink bollworm incidence in *Bt* cotton.

MATERIALS AND METHODS

Field studies were undertaken in Vadodara and Kheda districts of Gujarat on incidence of pink bollworm *P. gossypiella* in *Bt* cotton during 2014-15 and 2015-16. This work was carried out under the project entitled "Online Pest Monitoring and Advisory Services" sponsored by NCIPM, New Delhi. Karjan, Dabhoi and Savli talukas of Vadodara district and Kapadvanj, Kathalal and Thasra talukas of Kheda district were selected for the purpose. In each taluka, three villages were selected for study (Table 1 and 3). Green bolls were collected randomly from 2 fixed plots and 2 random plots from each selected villages and observed carefully in the laboratory through destructive sampling method. Out of collected green bolls, healthy and damaged bolls were separated and counted. Based on these data, the percentage of green boll damage was worked out. Green bolls were collected three times during 2014-15 and four times during 2015-16.All selected plots were of BG-II, irrespective of events/varieties.

RESULTS AND DISCUSSION

Vadodara District

The data on an incidence of pink bollworm recorded picking-wise in Vadodara district during 2014-15 and 2015-16 are presented in Table 1 and 2, respectively.

2014-15

During first picking (1st week of December), higher (15.00 %) incidence of pink bollworm (green ball damage due to pink ballworm) was recorded in village Kandari of Karjan taluka followed by village Kuvarpura of Dabhoi taluka (10.83%) and Khanpur of Dabhoi taluka (5.83%). Minimum percentage of damaged bolls (1.67 to 4.16 %) due to pink bollworm was observed in rest of the villages of Vadodara district. During 3rd week of December, green bolls were also examined and infestation of pink bollworm was recorded to the tune of 10.00 to 79.16 per cent in different villages surveyed. The highest (79.16%) boll damage due to pink bollworm was recorded in the village Kandari of Karjan taluka followed by Ganpatpura (75.83%) of Karjan taluka. In rest of the villages, it was in the range of 10.00 to 30.83 per cent. Late season *i.e.* during 1st week of January, green bolls were also collected and dissected. Out of nine villages of Vadodara district, the highest (78.33%) green bolls infested by pink bollworm was recorded in village Kandari (Karjan taluka) followed by Ganpatpura (58.33%) and Bamangam (50.00%) of the same taluka. In rest of the villages, it was to the tune of 20.83 to 43.33 per cent (Table 1). Of the three talukas of district surveyed, the highest (43.79%) boll damage was found in Karjan taluka followed by Dabhoi (22.59) and Savli (12.50).

Among the different villages, higher damage was recorded in Kandari (57.50%) and Ganpatpura (45.55%) of Karjan taluka followed by Bamangam of Karjan taluka (28.33%), Kuvarpura of Dabhoi taluka (24.16%), Khanpur of Dabhoi taluka (24.17%). On an average 26.29 per cent green boll was recorded due to pink bollworm in Vadodara.

2015-16

The higher (62.50 %) incidence of pink bollworm was recorded in village Sadrna of Karjan taluka followed by village Kuvarpura of Dabhoi taluka (52.50%) and Kandari of Karjan taluka (38.33%) during first picking (1st week of November, 2015), whereas in rest of the villages, it was in the range of 10.00 to 11.25 per cent boll damage. During 2nd week of October, green bolls were observed and infestation due to pink bollworm was recorded to the tune of 2.50 to 56.25 per cent in different villages surveyed. The highest (56.25%) boll damage due to pink bollworm was recorded in the village Ganpatpura followed by Kandari (38.75%) of Karjan taluka. During 1st week of November, it was in the range of 8.75 to 53.75 per cent and higher (53.75%) infestation was found in Kuvarpura of Dabhoi taluka followed by Kandari of Karjan taluka with the incidence of 48.75 per cent. Late season *i.e.* during 1st week of December, green bolls were also collected and observed for the infestation. Among the different villages of Vadodara district, the highest (72.50%) green bolls infested by pink bollworm was recorded in village Kandari (Karjan taluka) followed by Sadarna (58.75%) and Vasantpura (52.50%) of Savli taluka. In rest of the villages, it was in the range of 15.00 to 50.00 per cent (Table 2). The highest boll damage was found in Karjan taluka followed by Dabhoi and

Table 1 Infestation of pink bollworm, *P. gossypiella* in Bt cotton in Vadodara district during 2014- 15

Taluka	Village	Field No.	Picking wise green ball damage (%) due to pink bollworm				
			1st	2nd	3rd	Av. of field/ villages	Av. of Talukas
Karjan	Kandari	F1	10.00	83.33	73.33	55.55	43.79
		F2	13.33	63.33	93.33	56.66	
		R1	13.33	86.66	63.33	54.44	
		R2	23.33	83.33	83.33	63.33	
			15.00	79.16	78.33	57.50	
	Bamangam	F1	0.00	53.33	40.00	31.11	
		F2	3.33	16.66	50.00	23.33	
		R1	6.66	40.00	33.33	26.66	
		R2	6.66	13.33	76.66	32.22	
			4.16	30.83	50.00	28.33	
	Ganapatpura	F1	0.00	83.33	33.33	38.89	
		F2	0.00	80.00	90.00	56.67	
		R1	10.00	66.66	83.33	53.33	
		R2	0.00	73.33	26.66	33.33	
			2.50	75.83	58.33	45.55	
Dabhoi	Kuvarpura	F1	16.66	26.66	33.33	25.55	22.59
		F2	26.66	46.66	23.33	32.22	
		R1	0.00	16.66	40.00	18.89	
		R2	0.00	26.66	33.33	20.00	
			10.83	29.16	32.50	24.16	
	Khanpura	F1	13.33	10.00	50.00	24.44	
		F2	0.00	30.00	33.33	21.11	
		R1	0.00	40.00	56.66	32.22	
		R2	10.00	13.33	33.33	18.89	
			5.83	23.33	43.33	24.17	
	Menpura	F1	0.00	20.00	16.66	12.22	
		F2	6.66	13.33	50.00	23.33	
		R1	0.00	10.00	50.00	20.00	
		R2	0.00	33.33	33.33	22.22	
			1.67	19.17	37.50	19.44	
Savli	Gulabpura	F1	0.00	16.66	16.66	11.11	12.50
		F2	0.00	23.33	30.00	17.78	
		R1	0.00	3.33	33.33	12.22	
		R2	6.66	20.00	20.00	15.55	
			1.67	15.83	24.99	15.83	
	Ghothada	F1	0.00	23.33	30.00	17.78	
		F2	6.66	20.00	13.33	13.33	
		R1	0.00	10.00	26.66	12.22	
		R2	0.00	63.33	13.33	5.55	
			1.67	14.17	20.83	12.22	
	Anjesar	F1	0.00	10.00	10.00	6.67	
		F2	3.33	6.66	33.33	14.44	
		R1	3.33	10.00	23.33	12.22	
		R2	0.00	13.33	20.00	11.11	
			1.67	10.00	21.67	11.11	
Average of district							26.29

Note: F: Fixed plot; R: Random plot; 1st picking: 04/12/2014; 2nd picking: 19/12/2014, and 3rd picking: 03/01/2015

Table 2 Infestation of pink bollworm, *P. gossypiella* in Bt cotton in Vadodara district during 2015- 16

Taluka	Village	Field No.	Picking wise green ball damage (%) due to pink bollworm					
			1st	2nd	3rd	4th	Av. of field/ villages	Av. of Talukas
Karjan	Kandari	F1	65.00	25.00	55.00	75.00	55.00	43.85
		F2	25.00	40.00	65.00	65.00	48.75	
		R1	25.00	50.00	60.00	90.00	56.25	
		R2	NF	40.00	15.00	60.00	38.33	
			38.33	38.75	48.75	72.50	49.58	
	Ganpatpura	F1	35.00	60.00	15.00	15.00	31.25	
		F2	25.00	65.00	35.00	10.00	33.75	
		R1	NF	60.00	30.00	30.00	40.00	
		R2	NF	40.00	70.00	20.00	43.33	
			30.00	56.25	37.50	18.75	37.08	
	Sadarna	F1	100.00	20.00	25.00	60.00	51.25	
		F2	25.00	40.00	45.00	50.00	40.00	
		R1	NF	30.00	35.00	60.00	41.67	
		R2	NF	35.00	40.00	65.00	46.67	
			62.50	31.25	36.25	58.75	44.90	
Dabhoi	Kuvarpura	F1	75.00	50.00	45.00	55.00	56.25	31.84
		F2	45.00	10.00	50.00	35.00	35.00	
		R1	40.00	20.00	20.00	15.00	23.75	
		R2	50.00	10.00	100.00	50.00	52.50	
			52.50	22.50	53.75	38.75	41.88	
	Khanpura	F1	40.00	20.00	45.00	25.00	32.50	
		F2	0.00	10.00	30.00	20.00	15.00	
		R1	15.00	50.00	45.00	10.00	30.00	
		R2	NF	20.00	50.00	25.00	31.67	
			18.33	25.00	42.50	20.00	27.29	
	Chhatral	F1	55.00	20.00	40.00	30.00	36.25	
		F2	5.00	30.00	45.00	30.00	27.50	
		R1	5.00	30.00	20.00	25.00	20.00	
		R2	NF	10.00	25.00	30.00	21.67	
			21.67	22.50	32.50	28.75	26.35	
Savli	Vasantpura	F1	25.00	15.00	25.00	20.00	21.25	17.61
		F2	10.00	15.00	30.00	60.00	28.75	
		R1	10.00	20.00	15.00	30.00	18.75	
		R2	15.00	5.00	10.00	100.00	32.50	
			15.00	13.75	20.00	52.50	25.31	
	Ghothada	F1	15.00	0.00	10.00	15.00	10.00	
		F2	10.00	0.00	5.00	15.00	7.50	
		R1	10.00	0.00	5.00	15.00	7.50	
		R2	10.00	10.00	15.00	15.00	12.50	
			11.25	2.50	8.75	15.00	9.38	
	Anjesar	F1	5.00	0.00	5.00	45.00	13.75	
		F2	15.00	0.00	15.00	15.00	11.25	
		R1	10.00	0.00	25.00	65.00	25.00	
		R2	10.00	0.00	5.00	75.00	22.50	
			10.00	0.00	12.50	50.00	18.13	
Average of district								31.10

Note: F: Fixed plot; R: Random plot; 1st picking: 07/09/2015; 2nd picking: 12/10/2015, 3rd picking: 02/11/2015 and 4th picking:07/12/2015

Savli in which per cent boll damage registered as 43.85, 31.84 and 17.61 per cent, respectively.

Looking to the average of four pickings, the higher incidence was recorded in Kandari (49.58%) and Ganpatpura (44.90%) of Karjan taluka followed by Kuvarpura of Dabhoi taluka (41.88%), Ganpatpura of Karjan taluka (37.08%) and Khanpur of Dabhoi taluka recorded 27.29 per cent infestation (Table 2). As per the report of Kranthi (2015), pink bollworm survival on BG-II was recorded significantly higher in 2012, 2013 and 2014 mainly in Amreli and Bhavnagar districts of Saurashtra while the damage ranged between 0-80 per cent on Bollgard II in Bharuch, Vadodara, Anand, Bhavnagar, Amreli, Junagadh, Rajkot, Surendranagar and Ahmedabad districts of Gujarat. This report is in conformity with the present findings.

Kheda District

The data recorded on incidence of pink bollworm recorded during 2014-15 and 2015-16 are represented in Table 3 and 4, respectively. In Kheda, three talukas *viz.*, Kapadvanj, Kathalal and Thasra were selected for the purpose during both the years.

2014-15:

The higher (14.17 %) incidence of pink bollworm was recorded in village Ladvel of Kathalal taluka followed by village Antisar of Kapadvanj taluka (9.17%) during first picking (1st week of December, 2014). Minimum incidence (0.83 to 4.17%) of pink bollworm was recorded in rest of the villages of Kheda district. The infestation of pink bollworm was also recorded during 3rd week of December and it was to the tune of 1.67 to 6.66 per cent in different villages surveyed. Late season *i.e.* during 1st week of January, green bolls were also collected for checking the infestation. Out of nine villages of Kheda district, the highest (16.66%) green bolls infested by pink bollworm was observed in village Laxmipura (Kathalal) followed by Shivnagar (10.00%) and Vishwanathpura (8.33%) of the Thasra and Kathalal taluka, respectively. In rest of the villages, it was in the range of 0.83 to 5.00 per cent (Table 3). Maximum percentage of infestation (8.61%) was found in Kathalal taluka followed by Thasra (5.37%) and Kapadvanj (2.59%).

On an average, the higher incidence was recorded at Laxmipura (10.55%) and Ladvel (8.89%) villages of Kapadvanj and Kathalal talukas, respectively followed by Vishwanathpura of Kathalal taluka (6.39%), Devnagar, Shivnagar (5.83 %) and Labhapura (4.44%) of Thasra taluka (Table-3).

2015-16

Comparatively higher (10.00 %) incidence of pink bollworm was recorded in village Thavad of Kapadvanj taluka, Labhapura and Ajupura of Thasra taluka during first picking (1st week of September, 2015). Minimum incidence (3.75 to 5.00%) of pink bollworm was recorded in rest of the villages. During 2nd week of October, green bolls were observed and it was in the range of 5.00 to 27.50 per cent in different villages under study. The highest (27.50%) boll damage due to pink bollworm was recorded in village Sikandar porda of Kathalal taluka followed by Vishwanathpura (21.25%) of Kathalal taluka. The observations for third picking of green ball damage due to pink bollworm was also made on 1st week of November and data showed that infestation was 8.75 to 16.25 per cent. The higher (16.25%) pink bollworm infestation was found in Vishwanathpura of Kathalal taluka followed by Mugatpura (15.00%) of Thasra taluka and Laxmipura (13.75%) of Kathalal taluka. During 1st week of December, green bolls were also collected and observed for the infestation. Out of nine villages of Vadodara district, the highest (31.25%) infested green bolls were observed in village Mugatpura followed by Labhapura (28.75%) of Thasra taluka. In rest of the villages, it was in the range of 20.00 to 25.00 per cent (Table 4).

Looking to the average infestation of three pickings, higher incidence was recorded in villages Labhapura (28.75%) of Thasra taluka followed by Ladvel (19.58%), Shivnagar (19.38%), Vishwanathpura (19.06%), Laxmipura (15.00%), Devnagar (14.69%), Thavad (11.56%), Antisar (10.63%) and Kashipura (9.38%).

In nutshell, the incidence of pink bollworm in *Bt* cotton was higher in Vadodara district as compared to the Kheda district of middle Gujarat irrespective of different events/ varieties of BG-II.

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Table 3 Infestation of pink bollworm, *P. gossypiella* in Bt cotton in Kheda district during 2014 – 15

Taluka	Village	Field No.	Picking wise green ball damage (%) due to pink bollworm				
			1st	2nd	3rd	Av. of field/ villages	Av. of Talukas
Kapadvanj	Kashipura	F1	0.00	0.00	6.66	2.22	2.59
		F2	0.00	0.00	3.33	1.11	
		R1	0.00	0.00	10.00	3.33	
		R2	0.00	0.00	0.00	0.00	
			0.00	0.00	5.00	1.67	
	Antisar	F1	0.00	0.00	3.33	1.11	
		F2	20.00	3.33	0.00	7.78	
		R1	16.66	0.00	0.00	5.55	
		R2	0.00	3.33	0.00	1.11	
			9.17	1.67	0.83	3.89	
	Thavad	F1	3.33	6.66	3.33	4.44	
		F2	0.00	0.00	6.66	2.22	
		R1	0.00	0.00	6.66	2.22	
		R2	0.00	0.00	0.00	0.00	
			0.83	1.67	4.16	2.22	
Kathalal	Ladvel	F1	16.66	0.00	13.33	10.00	8.61
		F2	0.00	3.33	10.00	4.44	
		R1	10.00	13.33	3.33	8.89	
		R2	30.00	6.66	0.00	12.22	
			14.17	5.83	6.67	8.89	
	Vishwanathpura	F1	13.33	13.33	16.66	14.44	
		F2	0.00	6.66	3.33	3.33	
		R1	10.00	0.00	0.00	3.33	
		R2	0.00	0.00	13.33	4.44	
			5.83	5.00	8.33	6.39	
	Laxmipura	F1	0.00	6.66	3.33	3.33	
		F2	20.00	3.33	16.66	13.33	
		R1	6.66	0.00	26.66	11.11	
		R2	10.00	13.33	20.00	14.44	
			9.17	5.83	16.66	10.55	
Thasra	Labhapura	F1	0.00	6.66	10.00	5.55	5.37
		F2	0.00	3.33	3.33	2.22	
		R1	0.00	10.00	16.66	8.89	
		R2	0.00	0.00	3.33	1.11	
			0.00	5.00	8.33	4.44	
	Devnagar	F1	0.00	16.66	6.66	7.77	
		F2	0.00	6.66	16.66	7.77	
		R1	0.00	3.33	6.66	3.33	
		R2	13.33	0.00	0.00	4.44	
			3.33	6.66	7.50	5.83	
	Shivnagar	F1	10.00	6.66	6.66	7.77	
		F2	0.00	0.00	23.33	7.78	
		R1	0.00	0.00	10.00	3.33	
		R2	6.66	6.66	0.00	4.44	
			4.17	3.33	10.00	5.83	
Average of district							5.52

Note: F: Fixed plot; R: Random plot; 1st picking: 04/12/2014; 2nd picking: 19/12/2014 and 3rd picking: 03/01/2015

Table 4: Infestation of pink bollworm, *P. gossypiella* in *Bt* cotton in Kheda district during 2015 – 16

Taluka	Village	Field No.	Picking wise green ball damage (%) due to pink bollworm					
			1st	2nd	3rd	4th	Av. of field/ villages	Av. of Talukas
Kapadvanj	Kapadivav	F1	0.00	5.00	5.00	10.00	5.00	10.52
		F2	0.00	0.00	0.00	20.00	5.00	
		R1	0.00	10.00	15.00	40.00	16.25	
		R2	0.00	5.00	20.00	20.00	11.25	
			0.00	5.00	10.00	22.50	9.38	
	Antisar	F1	0.00	0.00	5.00	20.00	6.25	
		F2	5.00	10.00	5.00	25.00	11.25	
		R1	10.00	0.00	10.00	15.00	8.75	
		R2	0.00	10.00	20.00	35.00	16.25	
			3.75	5.00	10.00	23.75	10.63	
	Thavad	F1	5.00	10.00	5.00	20.00	10.00	
		F2	10.00	0.00	10.00	20.00	10.00	
		R1	15.00	5.00	5.00	20.00	11.25	
		R2	10.00	10.00	15.00	25.00	15.00	
			10.00	6.25	8.75	21.25	11.56	
Kathalal	Sikandar porda	F1	NF	20.00	10.00	25.00	18.33	17.88
		F2	NF	10.00	10.00	30.00	16.67	
		R1	NF	40.00	20.00	15.00	25.00	
		R2	NF	40.00	0.00	15.00	18.33	
			NF	27.50	10.00	21.25	19.58	
	Vishwanathpura	F1	0.00	15.00	20.00	20.00	13.75	
		F2	10.00	15.00	25.00	20.00	17.50	
		R1	NF	15.00	15.00	40.00	23.33	
		R2	NF	40.00	5.00	20.00	21.67	
			5.00	21.25	16.25	25.00	19.06	
	Laxmipura	F1	5.00	15.00	20.00	20.00	15.00	
		F2	NF	20.00	10.00	20.00	16.67	
		R1	5.00	0.00	15.00	20.00	10.00	
		R2	NF	25.00	10.00	20.00	18.33	
			5.00	15.00	13.75	20.00	15.00	
Thasra	Labhapura	F1	10.00	10.00	10.00	25.00	18.33	17.46
		F2	10.00	0.00	10.00	35.00	18.33	
		R1	NF	15.00	15.00	35.00	21.67	
		R2	NF	20.00	5.00	20.00	15.00	
			10.00	10.00	10.00	28.75	18.33	
	Ajupura	F1	10.00	5.00	0.00	30.00	11.25	
		F2	10.00	10.00	5.00	25.00	12.50	
		R1	NF	20.00	15.00	20.00	18.33	
		R2	NF	10.00	15.00	25.00	16.67	
			10.00	11.25	8.75	25.00	14.69	
	Mugatpura	F1	NF	5.00	10.00	25.00	13.33	
		F2	5.00	10.00	10.00	25.00	12.50	
		R1	NF	15.00	15.00	35.00	21.67	
		R2	NF	25.00	25.00	40.00	30.00	
			5.00	13.75	15.00	31.25	19.38	
Average of district								15.28

Note: F: Fixed plot; R: Random plot; 1st picking: 07/09/2015; 2nd picking: 12/10/2015, 3rd picking: 02/11/2015 and 4th picking:07/12/2015

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GAU Research Journal 42 (1) : 21-25 (January 2017)

Estimation of health status of tribal farm women of Sabarkantha district

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Received : 23 November, 2016

ABSTRACT

Women play multiple roles in a family as housekeepers and also equally important roles as wage earners and agricultural producers. However, very often they are subjected to malnutrition and form a group highly vulnerable to morbidity and mortality. A women's health will be less productive in the labour force. Sabarkantha is considered as one of the country's 250 most backward districts. The present study was conducted in Khedbrahma and Poshina talukas of Sabarkantha district. Five villages from these two selected tribal talukas were selected randomly for the study. Total ten villages were selected for the study. Ten tribal farm women from each randomly selected village were selected. Thus, hundred tribal farm women were selected for present study. A pre-tested interview schedule was administered to elicit the information regarding their socio-economic attributes and health status. The data were collected by personal interview. More than half of the respondents were illiterate and were having low income. Clinical signs and symptoms were also observed. While studying the morbidity profile of the tribal farm women it was observed that anemia was found to be most prevalent (16%) followed by gum & teeth problems (12%) and digestive tract disorders (10%). Majority (59%) respondents were recorded of having no history of illness which might be due to ill informed status about the disease and lack of diagnosis.

Key words: Tribal farm women, health status, malnutrition.

Women play multiple roles in a family, primarily as mothers and housekeepers and also equally important roles as wage earners, agricultural producers, nutrition providers etc. They are instrumental in the acquisition of food, its preparation, storage and distribution. However, very often they are subjected to malnutrition and form a group highly vulnerable to morbidity and mortality. A women's health will be less productive in the labour force (Lakshmi, 2014). Sabarkantha is economically backward and disadvantage district. In 2006 the Ministry of Panchayati Raj named Sabarkantha one of the country's 250 most backward districts (out of a total of 640). It is one of the six districts in Gujarat currently receiving funds from the Backward Regions Grant Fund Programme (BRGF). Dangs has the lowest percentage of villages having health centers. The second lowest is Kachchh, followed by Bhavnagar, Surendranagar, and Sabarkantha. The main occupation of tribal farmers of these talukas is agriculture and animal husbandry. The tribal farm women are performing duties which required higher physical fitness. Health is an important parameter for tribal farm women. Estimating disease prevailing conditions, nutritional deficiencies may help in knowing the healthy or unhealthy physical conditions of an individual. Thus, study on health status of tribal farm women of Sabarkantha district was felt necessary.

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MATERIALS AND METHODS

The present study was conducted in Sabarkantha district of Gujarat. Sabarkantha district has three tribal talukas *viz;* Khedbrahma, Poshina and Vijayanagar. Khedbrahma and Poshina talukas have low literacy rate. Thus these two talukas were selected purposively for the study. Five villages from these two selected tribal talukas were selected randomly for the study.

Total ten villages were selected for the study. Ten tribal farm women from each randomly selected village were selected. Thus, hundred tribal farm women were selected for present study. A pre-tested interview schedule was administered to elicit the information regarding their socio-economic attributes and health status. The data were collected by personal interview. The clinical signs were observed by researchers and noted as per the guidelines provided by Rao et al. (1954). The interpretation of clinical signs was made as per the procedure recommended by Jelliffe (1966). Data were interpreted in terms of percentage and frequency.

RESULTS AND DISCUSSION

Socio economic background of tribal farm women

The data presented in Table 1 shows that majority of respondents belonged to middle age group (45.00%) and young age group (44.00%), followed by old age group (11.00%). The majority (74.00%) of respondents were illiterate, followed by primary education (12.00%), higher secondary education (8.00%), and secondary education (6.00%). While 58.00 per cent of respondents had nuclear family while 42.00 per cent respondents had joint family. Majority of respondents had medium family (49.00 %) while nearly equal per cent of respondents had small and big family size. The data in Table 1 indicate that majority (76.00 %) of the respondents were having occupation of farming + animal husbandry followed by farming+ labour (14.00 %), farming only (7.00 %) and farming + service (3.00 %).

It was found that 59.00 per cent respondents had annual income up to Rs. 25000, 27.00 per cent from Rs. 25001 to Rs. 50000, followed by Rs. 50001 to Rs. 75000 (07.00 per cent), Rs. 75001 to Rs. 100000 (5.00 %) and above Rs. 100000 (2.00 %). Great majority (78.00 %) of the respondent had katcha house while 22.00 percent had pakka house. It is revealed that majority (44.00 %) of the respondents possessed herd size above 5 numbers followed by up to 5 numbers of animals (32.00 %). The data show that 60.00 per cent of the respondents were marginal farmers, followed by small (32.00 %) and medium (8.00 %). None of them was big farmer. Among the respondents 56 per cent of the respondents were non-vegetarian while 44 per cent were vegetarian.

This social scenario shows poor education, lower socio-economic conditions and large family size of majority tribal farm women. These factors can be considered as the main causative factors of poor health status of tribal farm women.

History of disease/disorder of the tribal farm women

Table 2 shows morbidity profile of the tribal farm women. Anemia was found in 16 per cent respondents. Nutritional anemia is a major problem for women in India and more so in the rural and Tribal belt (Basu, 2000). Gum & teeth problems were observed in 12 per cent respondents. Total 10 respondents were found suffering from digestive tract disorders followed by hypertension (3 %) and diabetes (1 %). This result is in line with NNMB data shows that the lowest prevalence of hypertension was observed in tribal of Gujarat (women: 6.3 %). Majority (59 %) respondents were recorded having no history of illness which might be due to ill informed status of the disease and lack of diagnosis. Further, they consume food produced at their own farm using less chemical fertilizer, insecticide and are minimal processed foods. It has also been observed that every day 5 to 10 KM walk is a common among tribal farm women.

Clinical investigations of the tribal farm women

Table 3 shows distribution of the respondents according to their clinical investigation. These clinical investigations represent nutritional deficiencies in the body. Nutritional deficiencies negatively impact health status of an individual. Total 40 percent respondents were found to have hair related problems and 23.00 per cent were found to have flag sign and dispigmented hair. Except dispigmentation (8 %) no remarkably changes were observed on face. Total 78 per cent respondents were found having healthy eye sight while 14 per cent were observed having pale conjunctiva and 8 per cent complained about night blindness. Angular scars, chilosis and stomatisis were observed in 6 per cent, 14 per cent and 17 per cent respectively. Edema of tongue was seen in 10 per cent and glossitis was in 5 per cent. Molted enamel and yellowish pigmented teeth were observed in 33 per cent respondents while carries was observed in 17 per cent respondents. Total 20 per cent respondents were complained about spongy and bleeding gums. Ridged nails were observed in 21 per cent respondents while brittle nails and spoon shape nails were observed in 13 per cent and 5 per cent respectively. These are the signs of anemia (Shrilaxmi, 2006) also. All these deficiency symptoms show impaired health of tribal farm women. Insufficient intake of food and unavailability of healthy and nutritious food may be due to low socio-economic conditions, wrong cooking methods, large family size and poor education could

Table 1 Distribution of the respondents according to their socio economic attributes

(n=100)

Sr. No.	Attributes	Classification	Frequency	Per cent
1	Age	Young (Up to 35 years)	44	44.00
		Middle (35 to 50 years)	45	45.00
		Old (above 50 years)	11	11.00
2	Education	Illiterate	74	74.00
		Primary education (1-7 Std.)	12	12.00
		Secondary education (8-10 Std.)	06	06.00
		Higher secondary education (11-12 Std.)	08	08.00
3	Type of family	Joint family	42	42.00
		Nuclear family	58	58.00
4	Family size	Small family (Up to 4 members)	25	25.00
		Medium family (5-8 members)	49	49.00
		Big family (Above 8 members)	26	26.00
5	Occupation	Farming only	07	07.00
		Farming + labour	14	14.00
		Farming + Animal husbandry	76	76.00
		Farming + Service	03	03.00
6	Annual income	Up to Rs. 25000	59	59.00
		Rs. 25001 to Rs. 50000	27	27.00
		Rs. 50001 to Rs. 75000	07	07.00
		Rs. 75001 to Rs. 100000	05	05.00
		Above Rs. 100000	02	02.00
7	Type of house	Katcha	78	78.00
		Pakka	22	22.00
8	Herd size	Herd size (up to 5 number)	32	32.00
		Herd size (above 5 number)	44	44.00
		Do not possess animal	24	24.00
9	Land holding	Marginal (Up to 1.00 ha)	60	60.00
		Small (1.01 to 2.00 ha)	32	32.00
		Medium (2.01 to 4.00 ha)	08	08.00
		Big (Above 4.00 ha)	00	00.00
10	Food habit	Vegetarian	44	44.00
		Non-vegetarian	56	56.00

Table 2 Distribution of the respondents according to their history of disease / disorder (n=100)

Sr. No	Disease/disorder	Frequency	Percent
1	Diabetes	01	01.00
2	Hypertension	03	03.00
3	Heart Disease	00	00.00
4	Anemia	16	16.00
5	Gum & teeth problems	12	12.00
6	Digestive tract disorders	10	10.00
7	Any Other	05	05.00
8	None	59	59.00

Table 3 Distribution of the respondents according to their clinical investigation (n=100)

Sr. No.	Signs and Symptoms	Frequency	Per cent
1.	Hair		
	A Lack of luster	6	06.00
	B Thinness and sparseness	9	09.00
	C Flag sign / dispigmented	23	23.00
	D Easy plukability	2	02.00
	E Normal	60	60.00
2.	Face		
	i) Diffuse depigmentation	8	08.00
	ii) Naso-labial dyssebacea	0	00.00
	iii) Moon face	0	00.00
	iv) Normal	92	92.00
3.	Eye		
	i) Night blindness	8	08.00
	ii) Pale conjunctiva	14	14.00
	iii) Xerosis	0	02.00
	iv) Xeropthalmia	0	02.00
	v) Bitot's spot	6	06.00
	vi) Normal	78	74.00
4.	Lips		
	i) Angular stomatitis	6	06.00
	ii) Angular scars	14	14.00
	iii) Cheilosis	17	17.00
	iv) Normal	63	63.00
5.	Tongue		
	i) Oedema	10	10.00
	ii) Scarlet and raw tongue	5	05.00
	iii) Magenta tongue	4	04.00
	iv) Glossitis	5	05.00
	v) Normal	76	76.00
6.	Teeth		
	i) Molted enamel & pigmented	33	33.00
	ii) Caries	17	17.00
	iii) Normal	50	50.00
7.	Gums		
	i) Spongy bleeding gums	20	20.00
	ii) Normal	80	80.00
8.	Nails		
	i) Brittle nails	13	13.00
	ii) Ridged nails	21	21.00
	iii) Spoon shape	05	05.00
	iv) Normal	61	61.00

be the possible reasons of nutritional deficiency signs and symptoms observed as clinical investigations and poor health of tribal farm women.

CONCLUSION

While studying the morbidity profile of the tribal farm women it was observed that anemia was found to be prevalent (16%) followed by gum & teeth problems (12%) and digestive tract disorders (10%). Majority (59%) respondents were recorded of having no history of illness which might be due to ill informed status about the disease and lack of diagnosis. Insufficient intake of food and unavailability of healthy and nutritious food may be due to low socio-economic conditions, wrong cooking methods, large family size and poor education could be the possible reasons poor health of tribal farm women. Awareness regarding health and nutritional facilities being availed by government and balanced diet choices may help in improve the health status of tribal farm women.

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GAU Research Journal **42** (1) : 26-35 (January 2017)

Performance evaluation of resource conservation machineries under rainfed condition of North-Gujarat region for greengram [*Vigna radiata* (L.)]

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Received : 22 April, 2016

ABSTRACT

Field experiment was conducted to evaluate tractive parameters among resource conservation machineries and conventional practice under leveled and unleveled plots for three consecutive years from *kharif*-2012 to *kharif*-2014, The field trials involved two main treatments *i.e.* No Leveling (L_0) and Leveling with laser land leveler(L_1) and five sub treatments *viz.*, zero till drill (M_1), roto till drill (M_2), strip till drill (M_3), raise bed planter (M_4) and conventional practices (M_5). The five sub-treatments *i.e.*, M_1, M_2, M_3, M_4 and M_5 were performed uniformly under L_0 and L_1. The experiments were carried out for greengram crop in the research farm of Centre for Watershed Management and Participatory Research and Rural Engineering, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat State. The result revealed that the treatment leveling with leser land leveler (L_1) offered 5.79 per cent higher effective field capacity (EFC), 0.77 per cent higher tractive efficiency, 6.50 per cent more fuel efficiency and 6.33 per cent less energy requirement than unlevelled plot (L_0). Among resource conservation machineries zero till drill (M_1) recorded higher effective field capacity and tractive efficiency of 0.504 ha/hr and 71.87 per cent, which was correspondingly 51.78 and 2.05 per cent more than conventional practices (M_5). Among all treatments, zero till drill (M_1) presented lowest Fuel consumption and energy requirement with corresponding value of 7.60 l/ha and 77.96 kWh/ha, which were 47.94 and 47.76 per cent lesser than conventional practices (M_5). The treatments strip till drill (M_3) and roto till drill (M_2) stood second and third reporting fuel consumption equivalent to 8.51 and 8.91 l/ha, respectively.

Key words: Resource conservation, tractive efficiency, power delivery efficiency, fuel efficiency, energy requirement, root profile.

The major research and development efforts in the 'green revolution' era focused on enhancing productivity of selected food grains and few other crops. The conventional mode of agriculture through intensive agricultural practices was successful in achieving goals of production, but simultaneously led to degradation of natural resources. The new challenges demand that efficient resource use and conservation receive high priority to ensure earlier gains can be sustained and further enhanced to meet the emerging needs. (Rao, 2013).

Resource conserving machineries refer to those practices that enhance resource or input-use efficiency. Zero or reduced tillage practices that save fuel and improve plot-level water productivity may also be considered RCTs, as may land leveling practices that help save water. Conservation tillage practices reduce the cost of operation, fuel consumption and time for operation of various crops (Sharma *et al.*, 2005). Recourse conservation technology offers the possibility of conserving natural resources and optimizing crop productivity through controlled soil erosion, reduced soil compaction, increased water use efficiencies and reduced energy costs (Hobbs, 2007).

The greengram [*Vigna radiata* (L.)], also known as mungbean is one of the important legume crops grown for their seed under rainfed condition. Kharif greengram was sown at the onset of monsoon with seed rate of 17.5 to 20 kg/ha with 45 cm distance between two

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rows. Objectives of the study was to study the effect of selected resource conservation machineries on tractive, fuel, power delivery efficiencies and energy requirement for rainfed greengram crop.

MATERIALS AND METHODS

The experiment was conducted in the Research Farm of Centre for Watershed Management Participatory Research and Rural Engineering, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar in three successive years of 2012, 2013 and 2014 during kharif season (July to October).

Four resource conservation machines i.e., Zero Till Drill (ZTD), Roto Till Drill (RTD), Strip Till Drill (STD), Raise Bed Planter (RBP) were selected under study. Laser beam guided Land Leveler (LLL) was chosen to identify the effect of land leveling on tractive, root profile and crop parameters. Cultivator and manually metered seed cum fertilizer drill which are largely used in the region were selected as a Conventional Practice (CP).

A 50 HP, 4 cylinder agricultural tractor was selected as a power source to conduct the study The parameters like speed of operation, slip, drawbar pull, fuel consumption and soil disruption were measured to study the effect of resource conservation machineries on effective field capacity, fuel efficiencies, energy requirement and soil volume disturbance. Experiment detail is shown in Table 1. The experiment was conducted in six replications and each replication plot was termed as main plot. Each main plot was divided into two treatments L_0 and L_1. L_0 stands for normal unleveled plot and L_1 was the plot subjected to leveling operation by means of laser land leveler. Five sub-treatments i.e., M_1, M_2, M_3, M_4 and M_5 were performed uniformly under L_0 and L_1. All agronomical parameters and agricultural operations were followed uniformly as per best recommendations laid down in the region for green gram crop.

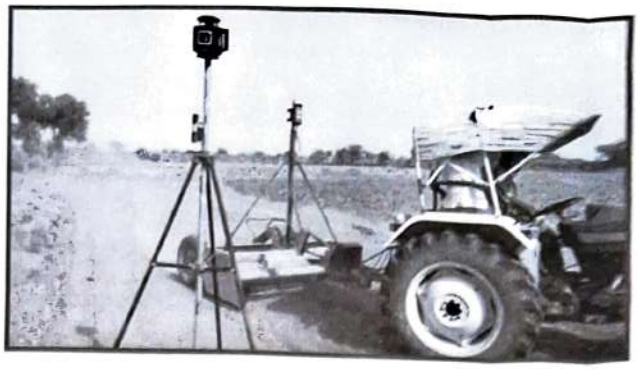
Table 1 Experiment details

Sr. No.	Code	Treatment details	Machinery / Equipment
		Main plot treatments	
1	L_0	No leveling	-
2	L_1	Leveling	Laser beam guided land leveler
		Sub plot treatment	
1	M_1	Zero till drilling	Zero till drill
2	M_2	Roto till drilling	Roto till drill
3	M_3	Strip till drilling	Strip till drill
4	M_4	Raise bed planting	One pass of cultivator + Raise bed planter
5	M_5	Conventional practice	Two pass of cultivator + Manually metered seed cum fertilizer drill

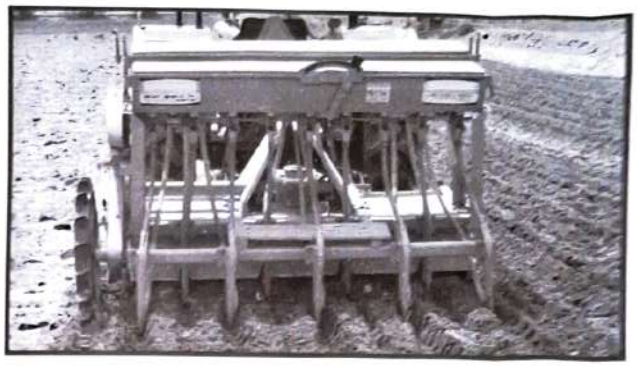
Field survey was conducted before commencing the experiment to undertake leveling operation in October-2011. Table 2 shows, the total area of experimental plot and area under precision land leveling.

Table 2 Particulars of the selected fields

Parameters	Size of experimental plot	Area under precisionlaser land leveler
Length of the field	100 m	
Width of the field	70 m	16.5 x 35 x 6 replication = 3465 m^2
Area of the field	7000 m^2	

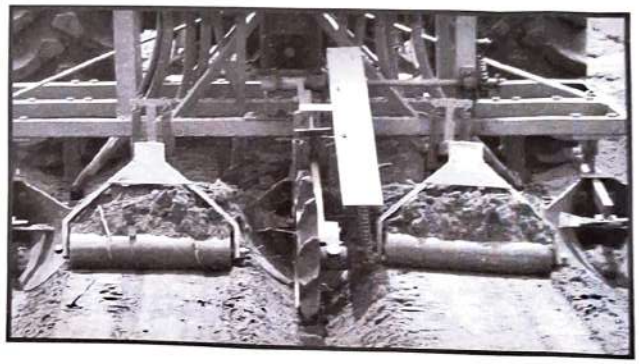


(i) Zero Till Drill (M_1)

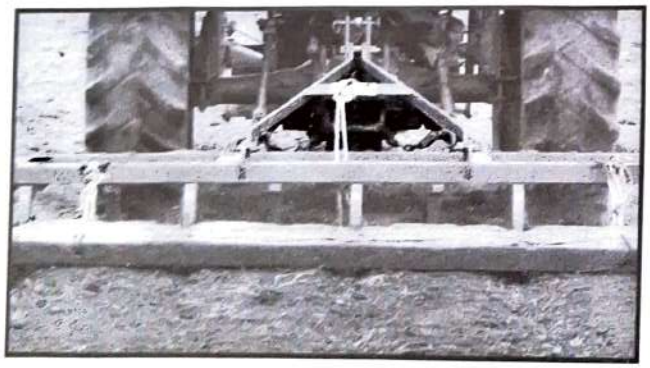


(ii) Roto Till Drill (M_2)

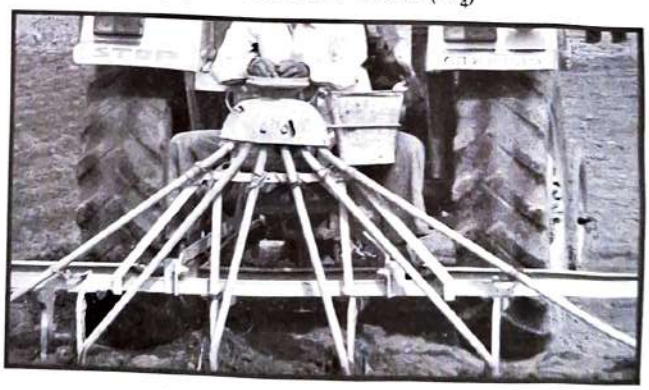
(iii) Strip Till Drill (M_3)



(iv) Raised Bed Planter (M_4)



(v) Cultivator with Wooden Plank (M_5)



(vi) Manual Seed Drill (M_5)

Fig. 1 Field survey and resource conservation practices in operation

A tractor operated laser land leveler was engaged for precision land leveling of the plot under treatment L_1. The experiment was conducted using split plot design. The analysis was carried out at significance level of 5 per cent.

RESULTS AND DISCUSSION

Field survey was carried out using Auto Level. The operating speed of laser land leveler, recorded for ten different observations and its average was taken as the travelling speed, which was found as 2.85 km h^{-1}. The average value of TFC, EFC and FE were calculated as 0.58 ha/hr, 0.21 ha/hr and 36.35 per cent, respectively. Average value of fuel consumption calculated for laser land leveler operation was found to be equivalent to 4.15 liter per hour. Fig. 2 shows the contour map of the experiment plot before and after leveling operation.

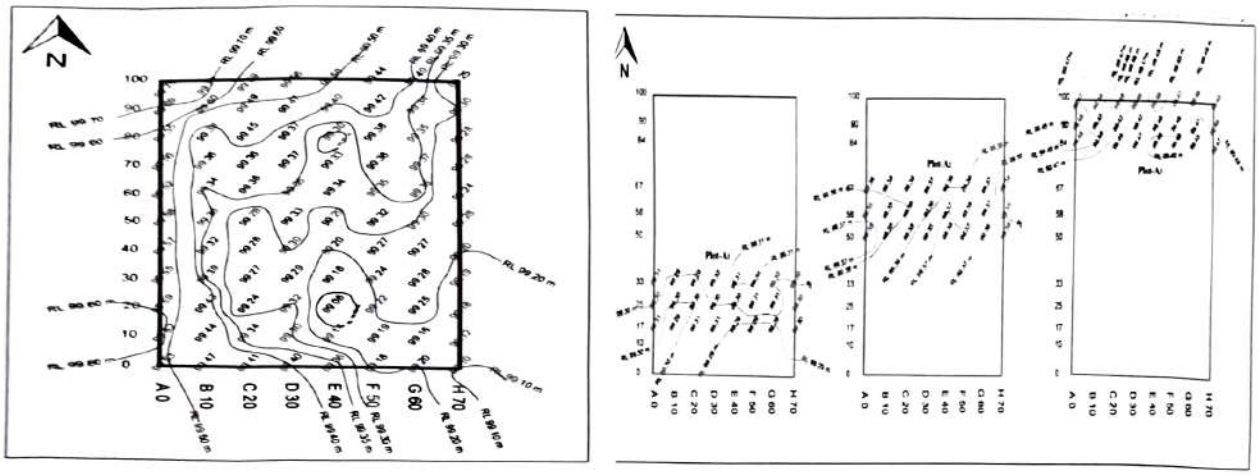


Fig. 2 Contour map before and after leveling operation

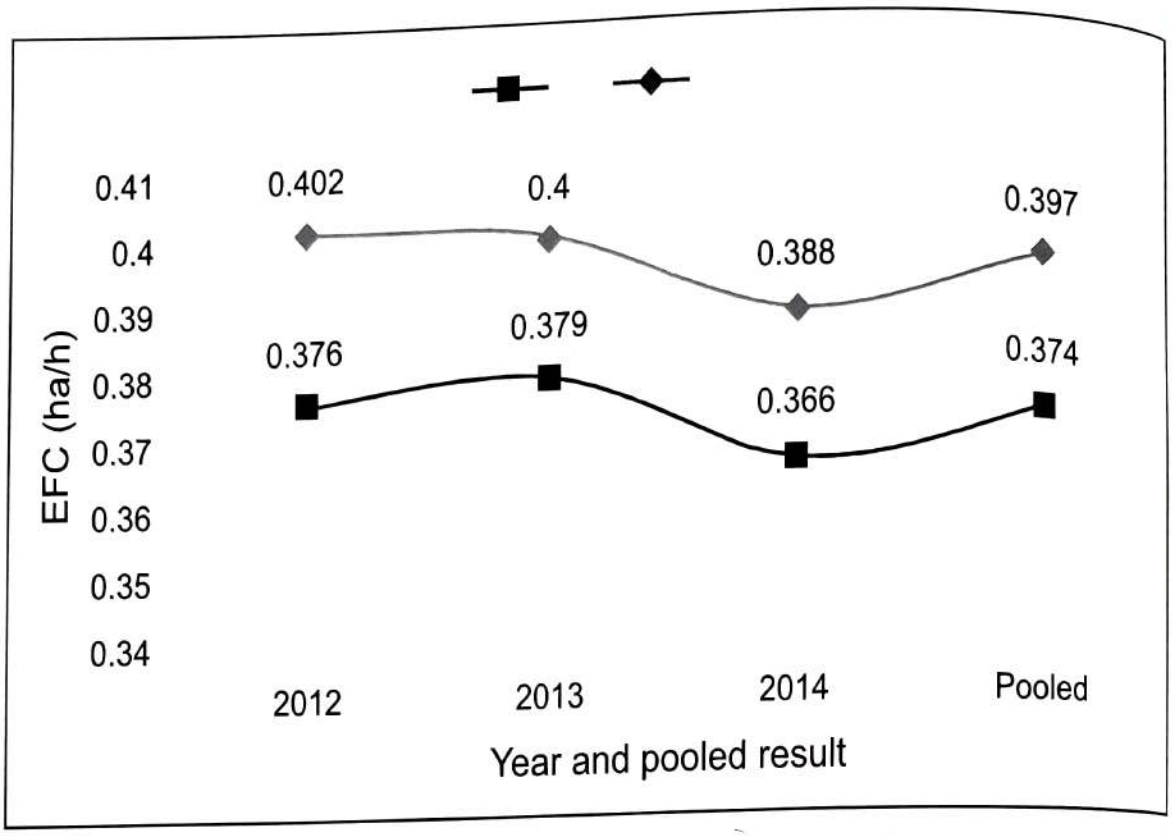
Effect of Resource conservation machineries on effective field capacity

The result revealed that effective field capacity was found significant and reasonably higher for the leveled experimental plot during all three year (i.e., 2012, 2013 and 2014) and in pooled result. Table 3 and Fig. 3 shows that, leveled plot witnessed upper value of effective field capacity in all three years with a pooled value of 0.397 ha/hr. The pooled result revealed that, leveled field presented 5.79 per cent higher EFC than no leveling treatment which was 0.374 ha/hr.

Pooled result obtained for sub plot depicted that zero till drill achieved highest EFC in all three years (0.504, 0.516 and 0.492 ha/h, respectively) as well as in pooled result (0.504 ha/h). Conventional practices took 51.78, 47.40, 45.75 and 9.66 per cent extra time to finish operation as compared to treatment ZTD, STD, RTD and RBP respectively.

Table 3 Treatment wise effective field capacity (ha/h)

Treatments	Years			Pooled
	2012	2013	2014	
Main plot				
L_0	0.376	0.379	0.366	0.374
L_1	0.402	0.4	0.388	0.397
S.Em. ±	0.006	0.007	0.006	0.004
C.D.	0.023	0.022	0.021	0.012
C.V.(%)	8.9	8.04	8.33	8.42
Sub-plot				
M_1	0.504	0.516	0.492	0.504
M_2	0.45	0.456	0.438	0.448
M_3	0.467	0.467	0.452	0.462
M_4	0.27	0.27	0.266	0.269
M_5	0.253	0.239	0.237	0.243
S.Em. ±	0.009	0.008	0.007	0.005
C.D.	0.026	0.023	0.021	0.015



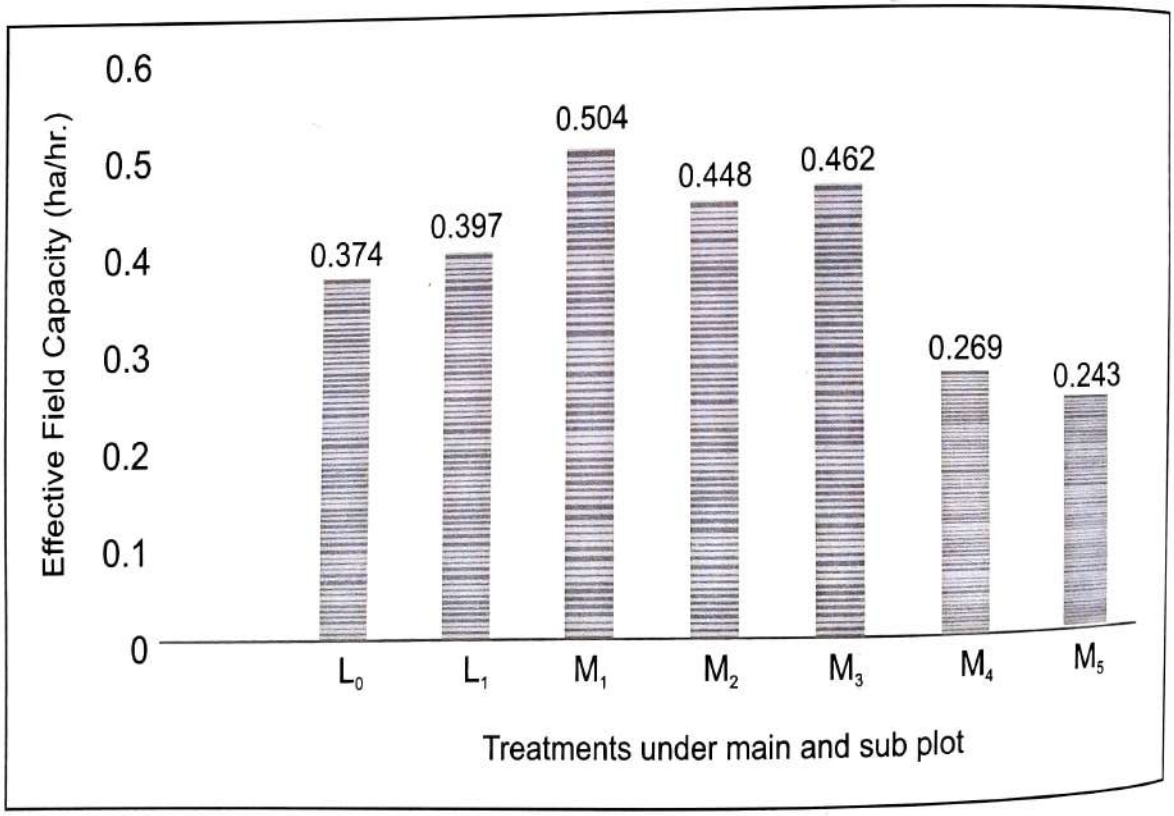


Fig. 3 Effective field capacity

Effect of Resource conservation machineries on tractive efficiency

Tractive efficiency found consistently higher for precisely levelled experimental plot than unleveled plot for three consecutive year of field experiment. Pooled result showed that leveled plot observed 0.77 per cent more tractive efficiency as compared to its counterpart. The reason may be the lesser slip exhibited by all treatments under precision leveled field. Pooled result shown in Table 4 and Fig. 4 revealed that Zero Till Drill (ZTD) registered highest value of tractive efficiency of 71.87 per cent, while raise bed planter and conventional practices recorded lower value of tractive efficiency equivalent to 70.07 and 70.39 per cent respectively. All the treatments comprising RCM and CP have shown significant effect on tractive efficiency. Dahab and Mohmmed (2000) also reported 1% higher practical tractive efficiency for field.

Table 4 Treatment wise tractive efficiency (%)

Treatments	Years			Pooled
	2012	2013	2014	
Main plot				
L_0	70.7	70.67	70.53	70.63
L_1	71.23	71.19	71.13	71.18
S.Em. ±	0.14	0.14	0.16	0.085
C.D.	0.5	0.52	0.57	0.256
C.V. (%)	1.06	1.11	1.21	1.14
Sub-plot				
M_1	72.13	71.84	71.71	71.89
M_2	70.88	70.87	70.86	70.85
M_3	71.31	71.36	71.32	71.3
M_4	69.83	70.24	70.15	70.07
M_5	70.7	70.35	70.12	70.39
S.Em. ±	0.2	0.18	0.21	0.11
C.D.	0.56	0.52	0.59	0.31

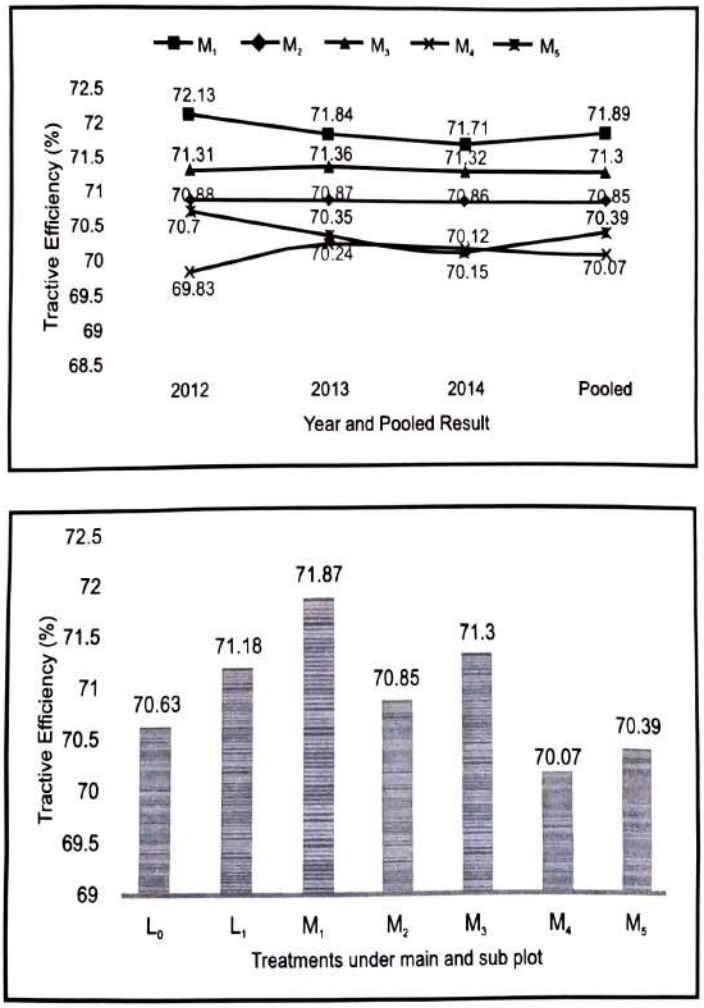


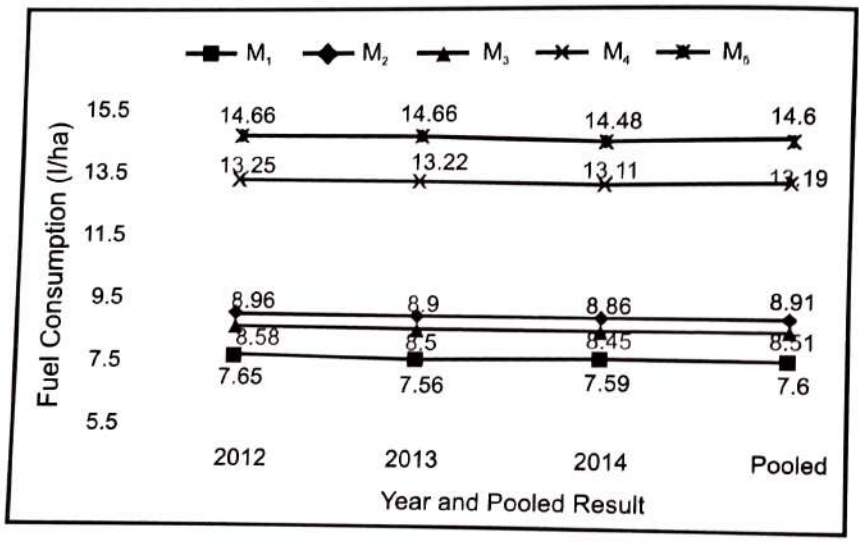
Fig. 4: Effect on tractive efficiency

Effect of Resource conservation machineries on Fuel efficiency

Pooled result of the trials showed significant effect on fuel consumption with a value of 10.92 l/ha and 10.21 l/ha found under unleveled and leveled plot, respectively. Table 5 and Fig. 5 presented that conventional practices recorded maximum fuel consumption of 14.66 l/ha which was attributed to longer duration of tractor work to accomplish farm operation (Two pass of cultivator followed by seed cum fertilizer drill). In terms of fuel consumption resource conservation machines contributed greater role. Zero till drill recorded minimum fuel consumption of 7.60 l/ha, brought down 47.94 per cent of fuel consumption as compared to conventional practices. Griso *et al.* (2003) also found the similar kind of result. Pankhurst (2000) and Coasts (2000) also confirmed that conventional tillage system are more energy intensive.

Table 5 Treatment wise fuel efficiency (l/ha)

Treatment	Years			Pooled
	2012	2013	2014	
Main plot				
L_0	10.95	10.98	10.82	10.92
L_1	10.29	10.16	10.18	10.21
S.Em. ±	0.15	0.12	0.14	0.069
C.D.	0.54	0.45	0.5	0.219
C.V. (%)	7.62	6.4	7.18	7.06
Sub-plot				
M_1	7.65	7.56	7.59	7.6
M_2	8.96	8.9	8.86	8.91
M_3	8.58	8.5	8.45	8.51
M_4	13.25	13.22	13.11	13.19
M_5	14.66	14.66	14.48	14.6
S.Em. ±	0.21	0.15	0.19	0.16
C.D.	0.6	0.43	0.53	0.51



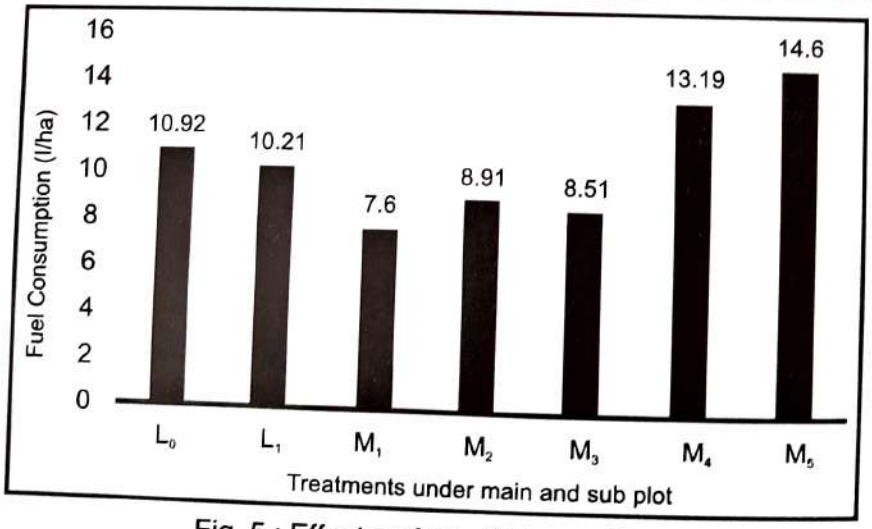


Fig. 5 : Effect on fuel efficiency (l/ha

Effect of Resource conservation machineries on energy requirement

Energy requirement is an important consideration in selecting farm machine/implement. Fig. 6 shows that maximum and minimum values of energy requirement recorded under L_0 and L_1 were 112.38 kWh/ha and 103.87 kWh/ha, reported in the year 2013 and 2014, respectively. Pooled result revealed that leveled field registered 104.51 kWh/ha energy against its counterpart which claimed 111.58 kWh/ha of energy requirement. The leveled plot found to have 6.33 per cent lesser energy requirement than unleveled plot.

Pooled result showed that zero till drill found to be efficient with lower energy requirement of 77.96 kWh/ha which was 47.76 per cent less than energy consumed by conventional practices.

Table 6 Energy consumption (kWh/ha)

Tretment	Years			Pooled
	2012	2013	2014	
Main plot				
L_0	112.25	112.38	110.12	111.58
L_1	105.49	104.16	103.87	104.51
S.Em. ±	1.26	1.24	1.17	0.70
C.D.	4.60	4.50	4.24	2.14
C.V. (%)	6.36	6.26	5.98	6.20
Sub-plot				
M_1	78.49	77.50	77.89	77.96
M_2	91.63	90.77	90.38	90.93
M_3	87.99	87.15	86.70	87.28
M_4	135.87	135.56	132.98	134.80
M_5	150.37	150.38	147.02	149.26
S.Em. ±	1.88	1.49	1.59	1.58
C.D.	5.38	4.25	4.54	5.16

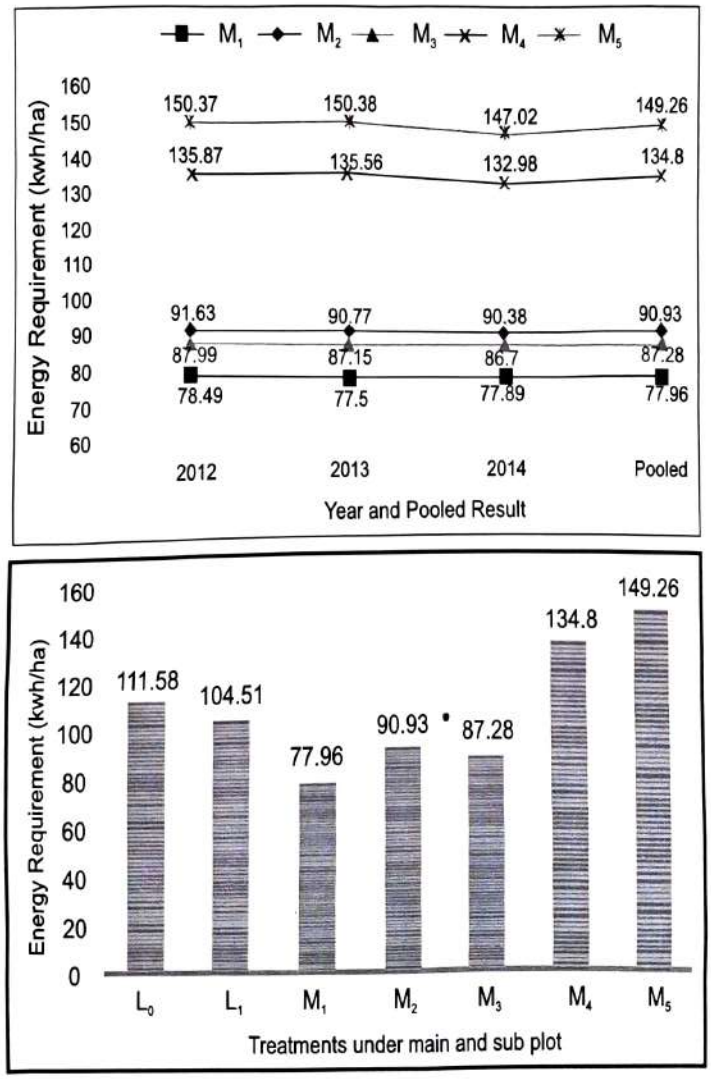


Fig. 6 Energy consumption (kWh/ha)

Table 7 Economics of different treatments.

Sr. No.	Parameters	ZTD	RTD	STD	CU+ RBP	CP	LL+ ZTD	LLL+ RTD	LLL+ STD	LLL+ CU+ RBP	LLL+ CP
		L_0M_1	L_0M_2	L_0M_3	L_0M_4	L_0M_5	L_1M_1	L_1M_2	L_1M_3	L_1M_4	L_1M_5
1.	Purchase price (₹)	39000	132000	102000	92000	28000	39000	132000	102000	92000	28000
2.	Salvage price (₹)	3900	13200	10200	9200	2800	3900	13200	10200	9200	2800
3.	Total life in years	10	10	10	10	10	10	10	10	10	10
4.	Depreciation (₹/hr)	11.70	39.60	30.60	27.60	8.40	11.70	39.60	30.60	27.60	8.40
5.	Interest (₹/hr)	7.15	24.20	18.70	16.87	5.13	7.15	24.20	18.70	16.87	5.13
7.	Repair and maintenance(₹/hr)	2.60	8.80	6.80	6.13	1.87	2.60	8.80	6.80	6.13	1.87
8.	Operator + Tractor charges (₹/hr)	274.37	280.33	277.97	259.84	258.12	271.90	282.90	279.12	254.63	256.35
9.	Cost of laser leveler (₹/hr)	0.00	0.00	0.00	0.00	0.00	841	841	841	841	841
10.	Total operating cost (₹/ha)	603	819	745	1185	1161	1408	1606	1546	1950	1928
11.	Cost of input and labour										
	i) Seed	1600	1600	1600	1600	1690	1600	1600	1600	1600	1669
	ii) Fertilizer	2160	2160	2160	2160	2296	2160	2160	2160	2160	2271
	iii) Labour(₹/hr)	2490	2465	2423	2211	2807	2515	2480	2495	2241	2896
12.	Total cost of input and labour (₹/ha)	6250	6225	6183	5971	6793	6240	6275	6255	6001	6836
13.	Total cost of crop production (₹/ha) (10 + 12)	6853	7044	6928	7156	7954	7648	7881	7801	7951	8764
14.	Greengram seed income (₹/ha)	36253	38752	37459	32740	35604	41630	43584	42257	37690	40199
15.	Straw income (₹/ha)	742	796	764	669	731	831	892	859	780	820
16.	Net Realization (₹/ha)	30143	32504	31295	26253	28381	34813	36595	35315	30519	32255

The economic analysis showed the zero till drill reported lowest cost of operation of ' 603.00 among all treatment. However yield of greengram seed was highest under roto till drill for both the condition of leveled and unleveled land, hence net realization found was also maximum for roto till drill with corresponding value of ' 32504 and ' 36595 on hectare basis.

CONCLUSION

The study concluded that all the resource conservation machineries responded well under leveled land condition when tested for the parameters *i.e.* effective field capacity, tractive efficiency, fuel efficiency and energy requirement. Among resource conservation machineries, zero till drill was found most efficient in terms of effective field capacity, tractive efficiency, fuel consumption and energy requirement with corresponding value of 0.504 ha/h, 71.89 %, 7.60 l/ha and 77.96 kWh/ha. When compared with conventional practices, zero till drill reported 51.78 % better effective field capacity, 2.05 % more tractive efficiency, 47.94 % less fuel consumption and 47.76 % less energy requirement.

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GAU Research Journal **42** (1) : 36-43 (January 2017)

Marketing channels for marketing of potato in india

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Received : 08 December, 2016

ABSTRACT

Marketing channels are important economic link between production and consumption and maintain a balance between supply and demand. These involve private, institutional and corporate sectors wherein number of intermediaries play important role. Different marketing systems such as conventional marketing, retail chains through corporate sector, contract farming, direct marketing, cooperative marketing and future trading are prevalent in the country. Marketing channels of potato in different potato growing states of India *viz.,* Uttar Pradesh, West Bengal, Bihar, Madhya Pradesh, Gujarat, Maharashtra, Karnataka, Punjab, Himachal Pradesh, Andhra Pradesh and Telangana have been reviewed. As many as 17 marketing channels have been identified which include. (1) Producer (P)- Commission agent (CA)- Wholesaler (WS)- Retailer (R)- Consumer (C), (2). P-CA cum WS-R-C, (3) P- Village Merchant (VM) – CA-R-C, (4) P-VM-WS-R-C, (5) P-VM-R-C, (6) P-Cold Storage (CS)-WS-R-C,(7) P-CS-CA-WS-R-C,(8) P- State Marketing Agency-R-C, (9) P-NAFED-R-C, (10) P-MARKFED-R-C, (11) P-APMC-WS-R-C, (12)P-APMC-Supermarket –C, (13). P-APMC-Processor-C, (14) Contract Farmer- Contractor cum Exporter- Importer, (15) P-CA/Exporter- Importer, (16) P-VM-CA/WS-Exporter-Importer and (17) P-Cooperative Marketing Society- Exporter- Importer. These major channels meet the demand of domestic and export market in India.

Key words : Potato, marketing, consumption

Potato (*Solanum tuberosum* L.) belonging to the family solanaceae is an important vegetable grown all over the world. It was introduced in India in the beginning of the 17th century by Portuguese navigators. The first record of its cultivation in India is in the year 1847 in the issues of "The Gardening Monthly," a magazine published from London. By the 19th century, potato was widely grown throughout the country (Marwaha *et al.* 2003). Potato popularly known as 'The king of vegetables', has emerged as fourth most important food crop in India after rice, wheat and maize. The crop produces more food per unit time and area with high nutritional value to sustain burgeoning population. It produces 47.6 kg of food/ha/day whereas wheat, rice and maize produce 18.1, 12.4 and 9.1 kg food/ha/day, respectively (Kumar and Pandey, 2008). It has been recognized as a wholesome food and richest source of energy in most of the countries where it forms an important part of the diet.

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The average productivity of potato in India is 20 t/ha which is more than the world average (17.2 t/ha). The per capita availability of potato has gone up to 23.5 kg/year from 5 kg/year in 1952, However, it is still far behind China (35.3 kg/year) and Russian Federation (122.0 kg/year) (Pandey et al. 2007). India is the 3rd largest potato producer in the world and accounts for about 8% of world potato production. However, its share in world potato export is only about 0.89% in volume and 0.52% in value terms. Potato is used to produce most popular value added products *viz.,* chips, french fries, potato powder, potato starch, potato flakes and baby food.

The top five potato growing states of India are Uttar Pradesh followed by West Bengal, Bihar, Madhya Pradesh and Gujarat. Since Uttar Pradesh and West Bengal contribute around 54.9% of total production, any minor deviation in these two states affects the total Indian production. In productivity Gujarat rankes first (30.8 MT/ha) followed by Punjab (25.1 MT/ha) and Uttar Pradesh (24.5 MT/ha) (Anonymous, 2015).

Gujarat ranks seventh in area, while fifth in total production and first in productivity of potato in the country. In Gujarat, potato is cultivated in nine districts out of 27 districts. The highest area under potato is in Banaskantha district (33500 ha) followed by Sabarkantha (16880 ha), Gandhinagar (8100 ha), Mehsana (6300 ha) and Kheda (3875 ha). The similar trend for total production exists. It was 10.72 lakh MT in Banaskantha district followed by Sabarkantha (5.52 Lakh MT), Gandhinagar (2.96 Lakh MT), Mehsana (1.52 lakh MT) and Anand (1.16 lakh MT).The major potato growing talukas in Banaskantha district include Dessa and Vadgam.

Potatoes are mainly sold in the regulated markets by the farmers. The steady growth of arrivals of commodities in the regulated markets is the result of the improvement and beneficial effect of the regulated markets owing to which the sale of agricultural produce in the village has been observed to dwindle over time. This has led to considerable improvement in the market structure, conduct and performance (Shriniwas, 2011).

Potato Marketing System

Conventional

Conventionally potatoes are taken to wholesale markets through different marketing channels and then go to consuming markets or consuming centres from these markets. A chain of market intermediaries such as field procurement/ assembling agents, forwarding agents, commission agents, wholesalers, and retailers are operating to complete marketing process. Out of these, commission agents and wholesalers may act at more than one point. Due to lesser quantity of produce flowing through a particular marketing chain, the marketing efficiency of the process is generally low. For example, most of the small retailers have target of earning Rs 200 per day and they accordingly adjust their marketing margins which may be up to 100% of their purchase price. With the changes in APMC act, doors have been opened for big corporate houses to come and join the business of retail in agriculture.

Retail Chains

At present Reliance (Farm Fresh), ITC (ITC Chaupal), Bharti, Pentaloon Retail (Big Bazaar), DCM Sriram Consolidated (Hariyali Kisan Bazar), Spencers Retail, Food Bazar, Adani Group (Agri Fresh), Godrej Agrovet and Subhiksha are some important names creating retail rush in this business. However, P Chengappa, Professor of Agricultural Marketing at the University of Agricultural Sciences, Banglore is of the view that fresh fruits and vegetables are a small part of this retail juggernaut and even if retail chains do very well, they will capture only 10 per cent of the market in another five to ten years. On one hand the new marketing system that eliminates market intermediaries by directly purchasing from the farmers and selling to the retailers, provides cheap and good quality produce; on the other it creates threat for the livelihood of estimated 1.2 crore street vendors and small retailers in our country. Out of 1.2 crore nearly 30 lac retailers are vendors are estimated to sell fruit and vegetables.

Future trading

Futures trading is an agreement between a buyer and a seller obligating the seller to deliver a specified asset of specified quality and quantity to the buyer on a specified date at a specified place and the buyer, in turn, is obligated to pay to the seller a pre-negotiated price in exchange of the delivery. However, for speculators futures trading is a process under which sellers make promises to deliver something they don't have; and buyers promise to accept delivery of something they don't want- and both legally break their promises. Here profit maximization is the prime objective of the speculator while loss minimization is hedger's aim. Both speculators and hedgers seldom allow future contracts to mature, by nullifying the contract with reverse sale or purchase of contracts. In India MCX, NCDEX and NMCE are the three major commodity future exchanges while the first two trade in potato. Price discovery, hedging and speculation are the main functions of future markets.

Contract farming

Contract farming is a written or verbal contract between buyer and seller of purchase/ sale of an agricultural commodity at pre defined terms and conditions. These terms and conditions are generally related to price, quantity and quality of the produce. Contract farming has been an important tool to cut risk in the procurement process of processing quality potatoes, seed potatoes and specialty potatoes. There are many contract farming models prevalent in various Indian states and some of them are exploitative too. The concept is still maturing in India and its popularization is required because from farmers' point of view contract farming can reduce price risk associated with excessive price volatility of farm produce. (Rana, 2014)

Direct marketing

The direct marketing system enables the farmers to meet the specific demand of wholesalers, traders, consumers according to their preferences from the farmers inventory of graded and certified produce on one hand and on other hand helps the farmers to take advantage of favorable prices. This system encourages the farmers to undertake sorting, grading and quality marking at their farms. This model has been introduced in the name of APNI MANDI in Punjab and in the name of RYTHU BAZARS in Andhra Pradesh for fruits and vegetables.

Co-operative marketing

The co-operative marketing is the system by which a group of farmers join together to carry on some or all the processes involved in bringing goods from producer to consumer. In other words, it is the association of cultivators / farmers for the purpose of helping them to market their produce in a more profitable way than private trade system.

The members of a potato co-operative society sell their surplus produce to the society. Member farmers sell their produce to the society and they get an advance. After collecting the potato from the member, the society either processes it or sells it in the *mandies* or to the processors. Sometimes, considering the unfavorable prices prevailing in the market, the society stores the produce and sells later at favorable price. As soon as the produce is sold, the society makes payment to the farmers. Thus, the co-operatives play a key role in the agricultural marketing process and they protect the interest of the farmers from exploitation of middlemen and secure better returns for their produce. The Potato Growers Co-operative Association in Gujarat, Farukhabad Co-operative Marketing Society in Uttar Pradesh etc. are associated with co-operative marketing of potato. Besides, there are other co-operative organizations like NAFED which is a well known organization because and its function as the National Apex Body of the cooperative marketing system in co-ordination with State level Marketing Federations, Regional and District level co-operative societies. The aim of NAFED is to promote co-operative marketing of agricultural produce including potato and to ensure the farmers to get ready market as well as remunerative price for their produce. (www.agrimarknet.nic.in/Potato Profile.pdf)

Marketing channels

Marketing plays an important role in the economy of a producer farmer. Marketing is not only an economic link between production and consumption but also seeks to maintain a balance between supply and demand in overall terms.. Efficient marketing system is an important means for raising the income level of the farmers. The involvement of various marketing functionaries increase the marketing cost but these are indispensible. It is well known that good marketing facilities, efficient marketing channels and other marketing mechanisms give higher net prices for the produce in the economy.

Marketing channels are routes through which agricultural products move from producers to consumers. The length of the channel varies from commodity to commodity, depending on the quantity to be moved, the form of consumer's demand and degree of regional specialization in production. A marketing channel is a set of practices or activities necessary to transfer the ownership of goods, from the point of production to the point of consumption. It is the way products and services get to the end-user, the consumer; also known as a distribution channel. A marketing channel may be defined in different ways:

Moore *et al.* (1973) defined marketing channel as the chain of intermediaries through whom the various food grains pass from producers to consumers constitutes their marketing channels. Kohls and Uhl (1980) defined marketing channel as alternative routes of product flow from producers to consumers.

A marketing channel is a set of practices or activities necessary to transfer the ownership of goods, from the point of production to the point of consumption. It is the way products and services get to the end-user, the consumer; also known as a distribution channel. Marketing Channels are set of inter dependent organization in the process of making a product or service available for the use or consumption (Kotler *et al.* 2007).

Marketing Channels are set of inter dependent organization in the process of making a product or service available for the use of consumption by the consumer or business user. (Kotler and Armstrong 2012).

I) Private

The different private agencies such as Producers, Commission agent, Wholesaler, Retailer and consumers are involved in the route of marketing channels of potato. These were:

Producer - Cold storage - Commission agent - Wholesaler –Retailer - Consumer

Producer - Commission agent - Wholesaler - Retailer - Consumer

Producer - Wholesaler - Retailer - Consumer (Fig 1)

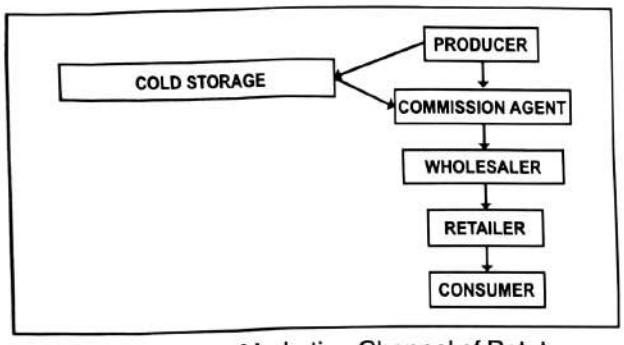

Fig 1 Private Marketing Channel of Potato

II) Institutional

Due to price fluctuations and glut situation in the market, some institutions like National Agricultural Co-operative marketing Federation (NAFED), different State Govt. Agencies, Co-operative Societies are intervening in the domestic market and Agricultural and Processed Food Export Development Authority (APEDA) for export purpose to stabilize the prices.

The institutions involve in the marketing channels of potato as follows:

Producer - State Marketing Agencies- Retailer - Consumer

Producer- Co-operative Societies- Retailer – Consumer

Producer- NAFED - Retailer – Consumer

Producer- Marketing Federation (MARKFED) – Retailer- Consumer (www.agrimarknet.nic.in/Potato Profile.pdf) (Fig 2)

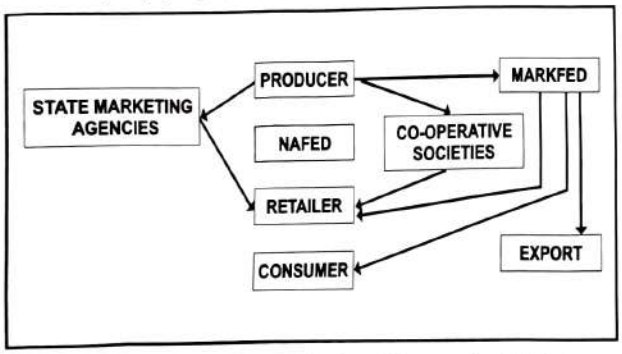

Fig 2 Institutional Marketing Channel of Potato

Marketing Channels Involved in Potato Marketing

Number of authors have described different marketing channels involved in marketing of potato which are briefly presented below:

Kiresur and Kumar (1988) examined the impact of regulation on vegetable marketing in India. They found that there were two common marketing channels through which the vegetables were sold. These were : Channel I- Producer – Commission Agent cum wholesaler – Retailer – Consumer and Channel II – Producer – Village merchant – Commission Agent- Retailer – Consumer. The Channel I was popular through which potato moves from farmers to producers. In the second channel, the village level merchant would get more profit than other marketing agents.

Vadiya (1995) found that the most popular marketing channels for potato existing in Shimla district was: (Producer – Depot holder – Commission agent – Consumer). About 80 per cent of potato in Shimla were marketed through this channel.

Saha and Mukhopadhyay (1998) examined the channels of potato marketing in Burdwan district of West Bengal. They observed that the channels of potato marketing played pivotal role by *arathdars* at the initial stage of marketing. The channel involving the flow of total marketed surplus from farmers to *arathdars* to wholesaler represents the dominant channel. The retailers purchase potato either at farm gate or at the *arathdars* and sell potato to the consumer from their own shop. The farmers perform transportation of crop, while the remaining functions of the market were done by *arathdars*. Among these, Channel I (Producer – Wholesaler – Retailer – Consumer) and Channel II (Producer - Retailer – Consumer) were found to be most popular.

Kerur *et al.* (1998) studied cost and marketing of potato in Dharwad district, Karnataka and identified two main channels for potato marketing. It was found that many farmers sold at low prices to village merchants due to perishability and the risk involved. The major marketing channels observed were: Channel I: Producer – wholesaler – Retailer – Consumer and Channel II: Producer – Village merchant – Wholesaler-Retailer – Consumer

Yadav *et al.* (2000) conducted a survey during 1996-97 in the Basti district of Uttar Pradesh. Three potato disposal channels (I: producer-consumer, II: producer-retailer-consumer and III: producer-wholesaler-retailer-consumer) were used.

In North Gujarat only two marketing channels for potato were identified during 2001-2002 in North Gujarat. Channel I consist of sale to consumer through wholesaler cum commission agent and retailer, while in Channel II produce moved through only retailer working as middleman between producer and consumer. Among these two channels, Channel I was found to be more popular dealing majority share of

total quantity sold. About 98.09 per cent was sold through this channel in Banaskantha district, while 98.31 per cent quantity was sold in Mehsana district whereas; only 1.91 percent and 1.69 per cent of produce were sold through channel II in Banaskantha and Mehsana districts respectively. (Anonymous, 2002)

Pandey *et al.* (2003) focused in their study both on the marketing system and estimation of postharvest losses in terms of physical and economic in Nalanda district, the leading potato growing district in Bihar and the major terminal market of Patna in India. Two marketing channels were identified: (i) Producer-cold store-wholesaler-retailer-consumer and (ii) Producer-wholesaler's field agent/wholesaler-retailer-consumer accounted for 46.8% potato disposal in Biharsharif block and 91.3% potato disposal in Noorsarai block respectively.

Thakar (2004) studied the marketing channels of potato in Banaskantha district of Gujarat and revealed that the sale of potato of selected farmers was done in market by Channel I and channel II, among which channel I was more popular than channel II. The major marketing channels observed were: Channel I : Producer – wholesaler cum Commission Agents – Retailer – Consumer and Channel II : Producer - Retailer – Consumer

Nikam *et al.* (2007) while studied the marketing of *kharif* potato in Satara district of Maharastra and reported that main marketing agencies through which the potatoes pass from producers to the final consumers was: Producer – *Hundekari* (Trasport agency)- Commission agent cum wholesaler- Retailer- Consumer.

Singh *et.al.* (2008) studied the system, method of sale and channel commonly used in marketing of potato in Ghazipur district (Uttar Pradesh). The study revealed that there were total four marketing channels prevailing in market: Channel I : Producer – consumer, Channel II: Producer – Retailer- Consumer, Channel III : Producer- wholesaler- Retailer- Consumer and Channel IV : Producer – Village Merchant- Retailer – Consumer

Ghulghule *et al.* (2009) studied the price spread in marketing of potato in Latur district of Maharashtra and observed three channels were observed *viz.*, Channel I: Producer - Commission agent cum Wholesaler - Retailer - Consumer, Channel II: Producer - Village Merchant - Commission agent cum Wholesaler - Retailer – Consumer and Channel III Producer - Retailer – Consumer. Maximum quantity was sold through channel - I (75.74 per cent) followed by channel - II (19.52 per cent), channel - III (3.88 per cent).

Nalini Ranjan Kumar *et al.* (2009) analyzed the supply chain management in potato export from India. They identified four supply chains: Channel I : Contract farmer- contractor cum exporter – Importer, Channel II: Potato producer - commission agents/ exporters- Importer, Channel III: Potato producers - village traders- commission agents / wholesalers cum exporter-Importer and Channel IV Potato producer - co-operative marketing society - exporters- Importer.

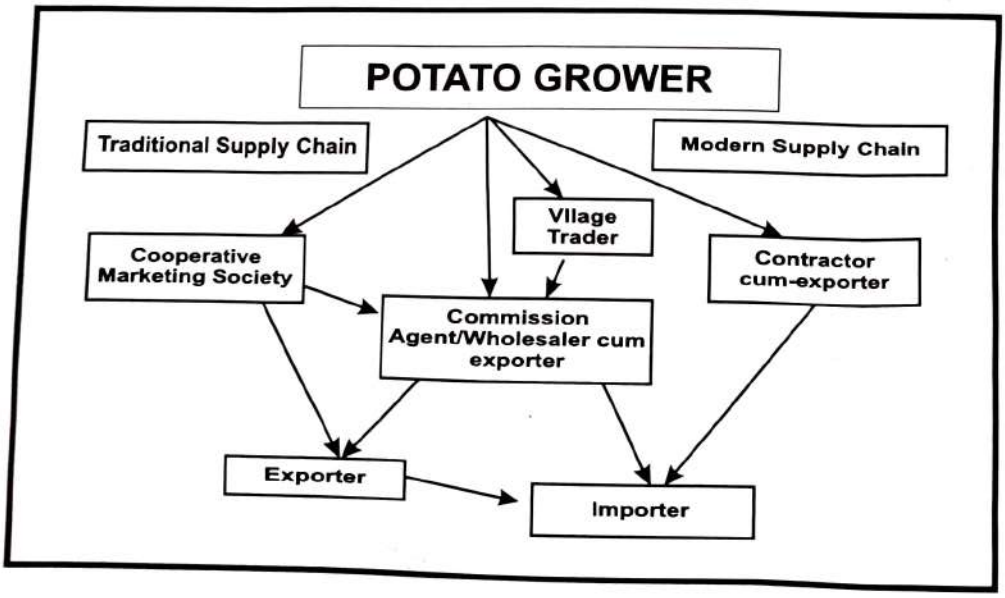

Fig 3 Supply Chains for Export of Potato

These supply chains can be categorized into two viz., modern supply chains and traditional supply chains. Modern supply chains are of recent origin in which potatoes for export are sourced through contract farming. In this supply chain there is flow of information from consumer to farmers through importer to contractor and then to farmers. In the traditional supply chains, potatoes for export are sourced through market from farmers who are not cultivating under contract farming. In this supply chain flow of information is very poor. They further identified a modern supply chain management practice for potato export. The supply chain activities in the modern marketing channel starts from selection of potato varieties as per market demand and is decided by the contracting firm based on the demand of processing firms and importers (Fig. 3).

National Centre of Agriculture Economics and Policy Research (NCAE & PR) (2010) conducted a study on supply chain network for selected vegetables in Andhra Pradesh. For potato, the movement from Farmer (Producer) to Consumer was depicted in Fig 4.The main channels involved were: Channel I: Producer-Middleman – Wholesaler- Retailer- Consumer, Channel II : Producer– Wholesaler- Retailer- Consumer and Channel III: Producer– Retailer- Consumer

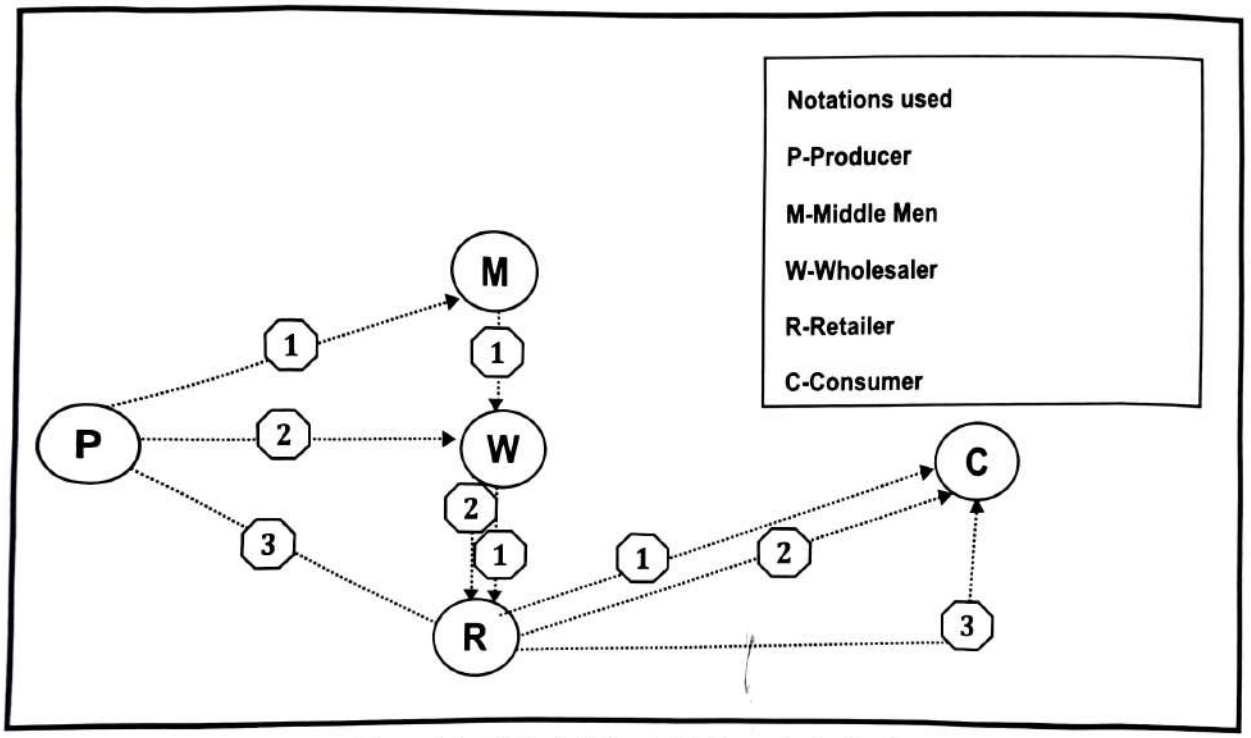

Fig 4 Supply Chain Network for Selected Vegetable Crops including Potato in Andra Pradesh

Shriniwas (2011) studied marketing of potato in Hassan and Belgaum districts of Karnataka State. It was revealed that farmers sell their produce in regulated markets either to commission agents or to the wholesaler which was quiet substantial (64%). Nearly 28% farmers also sell at village level and hardly few farmers (8%) were involved in the direct sale. The major marketing channels observed were: Channel I : Producer – Wholesaler - Retailer – Consumer (Hassan), Channel II : Producer – Commision agent – Wholesaler – Retailer – Consumer (Hassan), Channel III : Producer – Village level trader – Wholesaler – Retailer – Consumer (Belgaum) and Channel IV :Producer – Commision agent – Wholesaler – Retailer – Consumer (Belgaum).

Shashikant Singh (2011) studied the supply chains of potato in Bihar and identified two common supply chains during peak season and off season. Supply chain during peak season (February – March) was: Farmer- APMC Market (Mandi)- Wholesaler – Retailer – Consumer and Supply chain during off season (June – August) was: Farmer – Aggregator- Cold Storage – Wholesaler –Retailer- Consumer

Sidhu et al. (2012) studied the supply chains of potato in Punjab and revealed that there were mainly three supply chains exists. These were: Channel I : Producer – Wholesaler (through commission agent) –Retailer – Consumer, Channel II: Producer – Retailer (through commission agent)- Consumer and Channel III : Producer- Consumer.

Kumar and Vasudev (2015) identified five major marketing channels in the supply chain of Potato crop in Telangana. They were: Channel I: Producer – APMC – Wholesaler – Retailer – Consumer, Channel II: Producer – APMC – Supermarket – Consumer, Channel III: Producer – APMC – Processor – Consumer, Channel IV: Producer – Wholesaler – Retailer – Consumer and Channel V: Producer – Retailer - Consumer

Sagar et al. (2015) identified three major supply chains for marketing of vegetables for the period 2009-2010 in Mandya district of Karnataka State. These were: Channel I: Farmer-Commission Agent 1 - Commission Agent 2 - Retailer-Consumer, Channel II: Farmer-Wholesaler-Retailer-Consumer and Channel III Farmer-Retailers-Consumer (SC-III). The channel I and channel II were followed by majority of the farmers in all vegetable crops under study.

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GAU Research Journal **42** (1) : 44-46 (January 2017)

Shifting area from major cereal crops to other crops in Saurashtra and Kutch in Gujarat

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Received : 29 August, 2016

ABSTRACT

The present study was made to examine the shift in area of major cereal crop in last five, five year plan periods (VIIIth : 1992-93 to 1996-97 to XIIth : 2012-13 to onwards) in Saurashtra and Kutch zone. In order to calculate shift in area, average area of eighth five year plan was taken as base and percentage change was worked out for successive five year plans for different crops. For the horticultural crops the average area of tenth five year plan was taken as base, due to unavailability of data for previous plans. The data on area of major cereal crops from 1992-93 to 2013-14 and for horticultural crops 2002-03 to 2013-14 were collected from Directorate of Agriculture, Gujarat state, Gandhinagar. Five year plan period wise shift in area of major cereal crops of Saurashtra and Kutch zone was calculated and the results showed that most of the cereal crops like rice, wheat, sorghum and bajra were sown 36.36%, 18.60%, 64.35% and 19.60%%, respectively decrease in area over VIIIth five year plan. The area of all the cereals were continuously decreased in XIIth plan and the area of cotton and horticultural crops (flowers, spices, and fruit crops) were continuously increased after Xth plan. It means the farmers switched over to the crops like cotton and horticultural crops, especially flower and spices crops from cereal crops in Saurashtra and Kutch zone.

Key words: Shifting area, five year plan, cereal, horticultural

Important crops of Gujarat state are groundnut, castor, mustard, wheat, cotton, tobacco, paddy, sorghum, pearl milllet, maize, isabgul, cumin, sugarcane, red gram and gram. In 2012-13, in Gujarat state production of rice was 14.79 lakh tonnes and the production of maize was 7.90 lakh tonnes, the productivity of rice during the period was 2136 kg/ha and the productivity of maize was 1727 kg/ha (Anonymous, 2012-13). Area shift towards high value commercial crops is vital for increasing farm income, productivity and overall employment in the agricultural sector. Several economic (price and income) and non-economic (food-security concerns) factors influenced farmers decisions at the farm level. Saurashtra & Kutch zone ; Amreli, Bhavnagar, Botad, Devbhumi Dwarka, Gir Somnath, Jamnagar, Junagadh, Morbi, Porbandar, Rajkot, Surendranagar, and Kutch included for the study. It has been shown that higher food requirements at home inhibit the extent of crop substitution decision of the farmers. However, farmers are less responsive to the changes in the prices of food grains (in terms of changing their consumption) as higher income from high-value crops provide adequate money to purchase food crops from the market. Their capacity to generate higher productivity along with better market prospects have been recorded to explain the decision of shift in area of traditional low value crops .

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MATERIALS AND METHODS

The data on area of major cereal crops from 1992-93 to 2013-14 and for horticultural crops 2002-03 to 2013-14 were collected from Directorate of Agriculture, Gujarat state, Gandhinagar. An attempt was also made to examine the shift in area of major cereal crop in last five, five year plan periods (VIIIth to XIIth). In order to calculate shift in area, average area of VIIIth five year plan was taken as base and percentage change was worked out for successive five year plans for different crops. For the horticultural crops the

average area of Xth five year plan was taken as base, due to unavailability of data for previous plans.

RESULTS AND DISCUSSION

Five year plans period wise shift in area of major cereal crops for Saurashtra and Kutch zone

In order to calculate shift in area, average area of eighth five year plan was taken as base and percentage change was worked out for successive five year plans for different crops. For the horticultural crops the average area of Xth five year plan was taken as base, due to unavailability of data for previous plans. Five year plan period wise shift in area of major cereal crops of Saurashtra and Kutch zone was calculated and the results are presented in Table 1. The results revealed that the most of the cereal crops like rice, wheat, sorghum and bajra were sown 36.36%, 18.60%, 64.35% and 19.60% decrease in area over VIIIth five year plan. Area of total cereals decreased

Table 1 Five year plans period wise shift in area under major cereal crops for Saurashtra and Kutch zone for the period of 1992-93 to 2013-14

Crops	Five year plans wise average area (Lakh ha.)				
	VIIIth (1992-93 to 1996-97)	IXth (1997-98 to 2001-02)	Xth (2002-03 to 2006-07)	XIth (2007-08 to 2011-12)	XIIth (2012-13 onwards)
Rice	0.011	0.007 (-36.36)	0.006 (-14.28)	0.007 (+16.66)	0.003 (-57.14)
Wheat	1.72	1.40 (-18.60)	2.02 (+44.28)	4.59 (+127.22)	2.97 (-35.29)
Maize	0.088	0.104 (+18.18)	0.061 (-41.34)	0.084 (+37.70)	0.032 (-61.90)
Sorghum	2.02	0.72 (-64.35)	0.40 (-44.44)	0.42 (+5.00)	0.18 (-57.14)
Bajra	5.56	4.47 (-19.60)	3.49 (-21.92)	2.25 (-35.53)	1.20 (-46.66)
Total Cereals	9.40	6.71 (-28.61)	5.97 (-11.02)	7.36 (+23.28)	4.46 (-39.40)
Cotton	7.06	9.36 (+32.57)	10.39 (+11.00)	15.84 (+52.45)	17.47 (+10.29)
Total Oilseeds	20.22	21.11 (+4.40)	22.27 (+5.49)	20.60 (-7.49)	17.43 (-15.38)
Groundnut	18.24	17.47 (-4.22)	18.59 (+6.41)	17.19 (-7.53)	12.97 (-24.54)
Total Pulse	1.85	1.89 (+2.16)	1.58 (-16.40)	2.12 (+34.17)	2.06 (-2.83)
Flower	-	-	0.006	0.012 (+100.00)	0.0178 (+48.33)
Spice	-	-	2.11	2.72 (+28.90)	3.18 (+16.91)
Vegetable	-	-	1.54	1.47 (-4.54)	1.46 (-00.68)
Fruit	-	-	0.91	1.07 (+17.58)	1.22 (+14.02)
Total Horti.	-	-	4.57	5.27 (+15.31)	5.87 (+11.38)

Note : Values in parenthesis indicate percent change in area over previous five year plan period

by 28.61%, while area of cotton crop was increased by 32.57% in IXth plan over VIIth plan. It clearly indicates that there was shift in area from cereal crops to cotton crops. Tenth five year plan was witnessed of decrease in area under all *kharif* cereal crops. Maximum decrease was found in sorghum (44.44%) followed by maize (41.34%) crop. Cotton crop had considerable increment in area (11.00%) due to introduction of Bt cotton. Area of total cereals and total pulses was decreased in Xth plan by 11.02% and 16.40% respectively, over IXth plan. It indicates the shift of area in cotton crop. There was increment in area of all cereal crops except bajra crop in XIth plan over tenth plan. There was increment in area of wheat by 127.22%, of rice by 16.66%, of maize by 37.70% in XIth plan. Cotton crop showed considerable increment in area by 52.45%, while area of total oilseeds and groundnut decreased. Area under total horticultural crops was increased by 15.31% in XIth plan but area of vegetable crops was decreased by 4.54% over Xth five year plan. Almost all the cereals lost nearly half of their area in XIIth plan over eleventh plan. Area of rice, wheat, maize, sorghum and bajra was decreased by 57.14%, 35.29%, 61.90%, 57.14% and 46.66% respectively. There was increment in area of cotton crop by 10.19% in XIIth. Horticultural crops have increment in area (11.38%) over eleventh plan. It is cleared from analysis that area of all the cereals was continuously decreased in XIIth plan and the area of cotton and horticultural crops (flower, spice, and fruit crops) was continuously increased after tenth plan. It means the farmers switched over to the crops like cotton and horticultural crops, especially flower and spice crops from cereal crops in Saurashtra and Kutch zone. Sabesh *et al.* 2014 studied that Bt. cotton has brought a new cropping pattern and large scale shift in cotton cultivation has taken place in Vidarbha, Eastern Marathwada and Khandesh region in Maharashtra.

CONCLUSION

Five year plans period wise shift in area under major cereal crops was examine for the period of 1992-93 to 2013-14. Area of the major cereal crops was found decreasing after XIth plan. At the same time area of cotton and horticultural crops was found increasing.

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The determination of economically optimum nitrogen dose in cress (*Lepidi umsativum* L.) production under middle Gujarat conditions

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Received : 06 September, 2016

ABSTRACT

A field experiment conducted during rabi season of the year 2014-15 at Medicinal and Aromatic Plant Research Centre. BACA, Anand Agricultural University, Anand, Gujarat. Nitrogen fertilization assumes substantial influence in improving the yield of cress crops. The relationship between cress seed yield and nitrogen dose applied was determined by quadratic model and the economically optimum nitrogen dose was calculated via marginal analysis for yield maximization and profit over fertilizer cost. To determine optimum nitrogen dose in cress production under middle Gujarat conditions, data obtained by field experiments carried out in 2014-15. Economically optimum dose of nitrogen for cress crop was found to be 99.93 kg ha^{-1} under middle Gujarat conditions during 2014-15. Over-fertilized condition of nitrogen for maximum output did not bring out any significant advantage viewing almost identical seed yield both at physical and economic optimum of nitrogen indicating a saving of nitrogen 0.29 kg ha^{-1}.

Key words : Nitrogen dose, cress seed yield, marginal analysis, quadratic function

India is a country with more than 5000 yrs old civilization. Obviously, wealth of its traditional knowledge systems related to the use of plant species is as old and time tested. Plants have played a great role in the sustenance and development of human race offering food, fodder, fuel wood, timber, dyes, latex, gum, fibers, fruits, etc. People have been using medicinal plants from time immemorial for the treatment of various types of diseases. For instance, juice of basil tulsi (*Ocimum tenuiflorum* L.) leaves and honey partaking regularly for six months for expelling renal stones and its acting anti-diarrheal dysentery agents. The metanolic extract of neem (*Azardirachla indica* A. Juss) leaves is used as an antiviral agent (Badam *et al.* 1999).

The species sativum is native of Ethiopia and introduced to Europe, Asia and USA. In India, its cultivation is spread in patches across the states of Madhya Pradesh, Uttar Pradesh, Rajasthan, Gujarat and Maharashtra in an area of about 5000 hectare (Choudhary *et al.*, 2010). In Gujarat, it is traditionally cultivated in north Gujarat, Kutch, middle Gujarat and some part of Bharuch district. One of traditional medicinal plants having high nutrients is cress (*Lepidium sativum* L.) popularly known as Asaliyo, Sialoo, Ariya, Hali, and Halim in Gujarati and chandrasoor in Sanskrit. It is a winter season annual herb belonging to family Brassicaceae which is botanically related to mustard, sharing similar tangy flavour and aroma. The major constraint limiting production of crop is poor fertility status of soil. The nitrogen is one of the universal deficient plant nutrients in Indian soils specially the loamy sand soils of semi-arid region of Gujarat and Rajasthan. An optimum supply of nitrogen is important for vigorous, vegetative growth and development of plants. Nitrogen is also an integral part of chlorophyll, which is the primary absorber of light energy needed for photosynthesis. The supply of nitrogen is related to carbohydrate utilization. When nitrogen supply is insufficient, carbohydrates are deposited in vegetative cells which will cause them to thicken. Nitrogen also plays a major role in early establishment of the leaf area and root development which enable efficient use of available inputs. Results of an experiment conducted at various

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parts of country indicated that cruciferous oil seed crops responded appreciably to nitrogen fertilization (Joshi *et al.*, 1998).

Consequently, heavy dose of nitrogen is required to meet the needs of the crop and exploiting its yield potential. Apart from major plant nutrients (N, P and K), nitrogen (S) fertilization assumes greater significance for improved seed yield and quality produce (Hussain *et al.*, 2011; Kumar *et al.*, 1981; Mc Grath and Zhao, 1996). There is no doubt that the increased use of inputs induces an upward shift in production function to the extent that a technological change is embodied in them. But, it is economically and environmentally important to supply sufficient amount of fertilizer to the crop plants for exploiting the desired yield potential. Optimum fertilizer application in the recent years has gained substantial importance to ensure a high quality product, optimum yield, more net profit and less environmental pollution (Alivelu *et al.*, 2006 and Belanger *et al.*, 2000). Contrary to this, sometimes over fertilization and insufficient fertilization application lead to economic losses (Grant, 2006). Therefore, it becomes imperative to fine tune fertilizer application as per the crop demand to make it more judicious, environmental friendly and economical (Antoniadou and Wallach, 2002 and Henke *et al.*, 2007). When we consider fertilizer and product prices, increasing the amount of the nitrogen will result in loss rather than profit for the producer and fertilizing the plant with nitrogen which exceeds the optimum amount will lead to a considerable loss in terms of yield (Engel and Bergman, 1997). In cases when the income to be obtained at the end of additional nitrogen application can not cover the additional cost. Due to the above-listed reasons, it is of great importance to determine appropriate fertilizer doses to be applied in cress crop. Therefore, the present investigation was planned to find out the cost effective economic optimum dose of nitrogen for cress crop in middle Gujarat region of India.

MATERIALS AND METHODS

The experiment was conducted during *rabi* season of the year 2014-15 at, Anand, The chemical test values of soil were low in organic carbon (18.69 kg ha^{-1}), low in available nitrogen (N) (242.32 kg ha^{-1}), medium in available phosphorus (23.60 kg ha^{-1}) and available potassium (174.2 Kg ha^{-1}). The total rainfall received during the crop growth period was 850 mm in 2014-15. Twenty four treatment combinations given in *rabi cress* crop comprised of four nitrogen level, three phosphorus levels and two sulphur levels were tested in a factorial randomized block design with three replications. The plot size for each treatment was 3.00 m x 4.00 m. The pure seeds of *cress* variety Gujarat Asaliyo-1were used in the experiment. Sowing was done manually in line in the previously opened furrows at 30 cm apart using the seed rate of 3.0 kg ha^{-1} on 16th November in 2014. The seeds were covered with soil manually for better germination. Half dose of nitrogen as per treatments and full dose of phosphorus (60 kg P_2O_5 ha^{-1}) were applied as basal dose through urea, and Diammonium phosphate, respectively. Remaining half dose of nitrogen was top dressed after one month as per schedule. Standard cultural practices as per state recommendations were followed till the harvest of the crop. At maturity, *cress* crop harvested from the net plot, dried and threshed manually to determine the seed yield which was then expressed in kg ha^{-1}.

To know the yields-fertilizer relationship, linear, quadratic, square root and mitscherlich models were tried. It was observed that the relationship between seed yield obtained and quantity of nitrogen applied was determined using quadratic model.

$$Y = a + b*X + c*X^2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

Where, Y = seed yield in kg ha^{-1}, X = quantity of nitrogen applied in kg $ha^{-1}$and a, b and c are the constants.

In the test analysis, only the seed yield of cress was considered as the dependent variable and the expected yields were worked out accordingly. The estimated maximum yield values in the model were obtained by finding the value of 'X' by equating the first derivative of the reaction equations to zero and replacing the same with whatever the figure stated above is obtained. On the other hand, economic optimum dose was determined via marginal analysis. The nitrogen fertilizer dose where the Marginal Revenue (MR) is equal to Marginal Cost (MC) was designated as the economically optimum dose. Total revenue (TR) function was calculated by multiplying production function with unit product price (Py). Accordingly, TR function was calculated as;

$$TR = Py * Y$$
$$Y = Py\ (a + bX + cX^2) \ldots\ldots\ldots\ldots\ldots 2$$

MR was calculated by differentiating the first order derivative of TR function. In the light of this explanation, MR can be calculated as;

$$MR=\frac{\partial TR}{\partial X}=bP_y + 2P_y cX \quad \text{.....3}$$

Total cost (TC) function was obtained by multiplying the price of the input used with the input amount. Accordingly, TC function is calculated as ;

$$TC = Px^*X \quad \text{..... 4}$$

Marginal cost (MC) function was calculated by differentiating the first order derivative of TC function. Maximum yield is achieved when the marginal production (MP) is equated to zero. MP can be worked out by differentiating the first order derivative of production function Y. MP is calculated as;

$$MP=\frac{\partial Y}{\partial X}=b + 2cX \quad \text{..... 5}$$

The average unit price of nitrogen (irrespective of the source) was taken as Rs. 6.1 kg^{-1}. However, the market price of cress seed was Rs. 60 kg^{-1}during 2014-15.

RESULTS AND DISCUSSION

The best fit response equation as explained by quadratic model to study the nitrogen management in cress crop under middle Gujarat conditions is given in Table 1. The test analysis indicated that more than 99.98 per cent of the total variation in cress seed yield was due to application of nitrogen during year 2014-15. Based on the regression analysis, the maximum possible yield potential that can be exploited with respect to the amount of nitrogen applied is shown in Fig 1.

The costlier fertilizers, poor resource base as well as lack of knowledge and aptitude of cultivators towards using fertilizers up to the recommended level still arise the question that up to what extent fertilizer application should be made to achieve the sustainable and profitable production level rather than using fertilizers to target maximum possible yield potential without keeping in view the economic returns and impairing environmental quality. Therefore, it becomes imperative to consider whether the additional income (MR) brought out by each unit of nitrogen added covers the risk of additional fertilizer cost (MC) or not. In this context, additional income obtained from the production amount (Y) by adding each additional unit of input used (X) is taken in to consideration. The ratio of the additional change observed in Y product to additional change in X factor and the ratio of X factor price to Y factor price should be equal at the point

Table 1 Estimation of the model determining the relationship between the nitrogen doses applied and cress crop yield obtained during 2014-15

Variable	Coefficients	Standard error	t-value	p-value	R^2-value
Constant	-147.25	32.6142	-0.4.51	0.1388	0.9998
X	36.087	0.7583	47.58	0.0134	
X^2	-0.1806	0.0041	-43.08	0.0148	

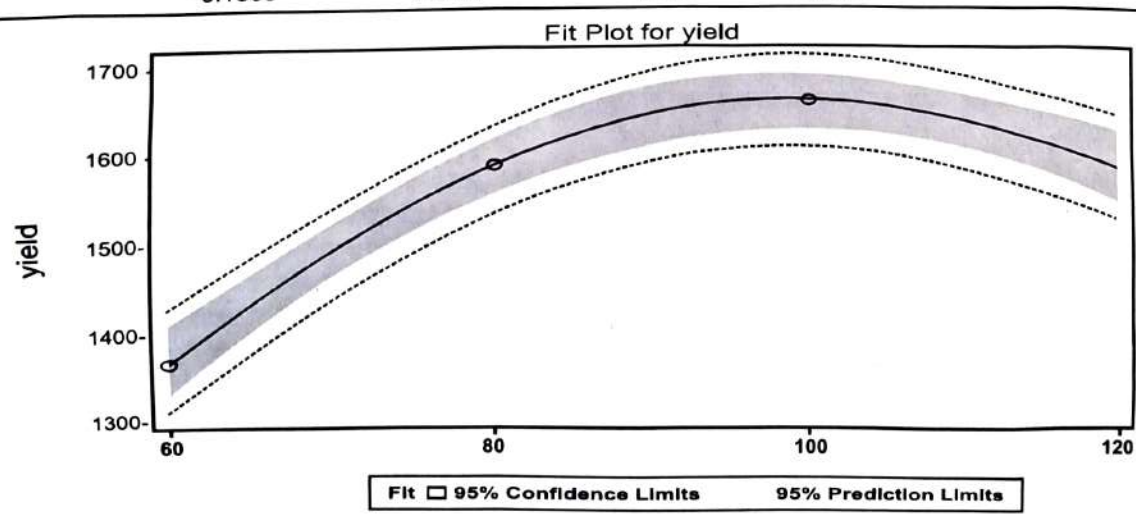

Fig 1 Predicting cress yield at different levels of nitrogen under middle Gujarat conditions using the regression equation (2014-15)

where MR is equal to MC for a profitable production to determine the economically optimum nitrogen dose.

To meet the objective of the study, the relationship between the amount of nitrogen applied and cress crop yield obtained for the year 2014-15 was worked out using a quadratic equation as under;

$$Y = -0.1806X^2 + 36.087X - 147.25 \quad R^2 = 0.99$$

TR function was obtained by multiplying the production function for the year 2014-15 with the product price (₹ 60 kg^{-1}) as;

$$TR = = -10.80X^2 + 2164.8X - 8835$$

MR function was obtained by first order derivative of TR function as;

$$MR = -21.6X + 2164.8$$

TC function was obtained by multiplying the price of the input used (₹ 6.1 kg^{-1}) with the input amount as; TC = 6.1 N. Marginal cost (MC) function was obtained by differentiating the first order derivative of TC function as; MC = 6.1

Optimum level of nitrogen was determined by equating MC with MR as; 6.1 = -21.6X + 2164.8, and X = 99.93 kg ha^{-1} was found to be the economical optimum dose of nitrogen for cress crop. However, the maximum seed yield due to nitrogen application, i.e., physical optimum dose can be achieved by the equating MP to zero as;

$$MP = \frac{\partial Y}{\partial X} = b + 2cX = 0$$

36.087 + 2* (-0.1806)*X = 0, and N = 100.22 kg ha^{1}. The optimum and maximum seed yield recorded with application of nitrogen was 1655.250 and 1655.480 kg ha^{-1} (Table 2).

The data presented in Table 2 further revealed that over fertilized condition of nitrogen did not show any significant yield advantage and the *cress* seed yield obtained with physical optimum and economic optimum of nitrogen was observed to be almost identical during the year. Thus, there can be a saving of nitrogen from 0.29 kg ha^{-1} without any reduction in seed yield of cress crop.

Table 2 Response function, optimum dose and seed yield in relation to nitrogen management in cress crop

Particular	2014-15	
	Economic optimum	Physical optimum
Response equation	$Y = -0.1806X^2 + 36.087X - 147.25$	
Nitrogen dose (kg ha^{-1})	99.93	100.22
Seed yield (kg ha^{-1})	1655.250	1655.480

CONCLUSION

Based on the results, it can be concluded that economic optimum yield of *cress* crop could be obtained with the application of nitrogen 99.93 kg ha^{-1} Profit can be increased by decreasing the nitrogen dose from maximum yield to the economically optimum dose.

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