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Evaluation of suitable varieties of groundnut with fertility levels for potato-groundnut system in North Gujarat

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ABSTRACT

A field experiment was conducted at Potato Research Station, S. D. Agricultural University, Deesa during summer 2017 to study the effect of varieties and fertility levels on yield, productivity and economics of groundnut. The results showed that variety TAG had significantly higher pod and kernel yields, and harvest index. Highest haulm yield and shelling % were recorded under DH 86. Highest crop productivity, gross and net returns and BCR were observed under TAG 24 which was closely followed by DH 86. Increase in fertilizer levels significantly enhanced 100 pod weight and 100 kernel weight significantly up to 50% recommended dose of fertilizer. However, highest pod yield and kernel yield were observed under 100% recommended dose of fertilizer which was statistically at par with 75% recommended dose of fertilizer. Maximum crop productivity, gross and net returns and BCR were registered under application of 100% recommended dose of fertilizer (12.5-25-0 kg $N:P_2O_5:K_2O$/ha) which was closely followed by 75% recommended dose of fertilizer.

Key words: Economics, Fertility levels, Groundnut, Kernel yield, Pod yield, Varieties

Groundnut (*Arachis hypogaea* L.) is the fourth most important source of edible oil and third most important source of vegetable protein in the world (Anonymous, 2017). Gujarat is the leading groundnut producer in India, occupying about 50 per cent of the total production. Recently, farmers are growing groundnut in summer season, especially in the northern Gujarat region after potato crop. It is a well-known fact that unsustainable agronomic practices such as excess or inadequate fertilizer use in the absence of standard soil test is a major abiotic factor affecting soil productivity, crop yield and subsequently farmers income at household level (Semoka, 2002). Identification of right amount of fertilizers considering the residual fertility level of the previous crop in a particular cropping system is required for realizing higher yield and income, without impairing environmental quality. Selection of appropriate variety for a particular region is essential for obtaining higher yield and remuneration. Hence, an experiment was planned to evaluate the effect of varieties and fertility levels on yield, productivity and economics of groundnut.

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MATERIALS AND METHODS

A field experiment was conducted at Potato Research Station, SDAU, Deesa (Gujarat) during summer season of 2017 to study the effect of varieties and fertility levels on yield, productivity and economics of groundnut. The soil was loamy sand in texture, low in organic carbon (0.32%), available nitrogen (173.52 kg/ha), medium in available phosphorus (23.10 kg P/ha) and available potassium (260.35 kg K_2O/ha). Treatments consisted of four varieties *i.e*., DH 86, TAG 24, TG 37A and GG 20 (Local check) in main plots and five fertility levels *viz.,*

No fertilizers, 25% RDF, 50% RDF, 75% RDF and 100% RDF in sub-plots and treatment combinations were laid out in split plot design and replicated thrice. The RDF of groundnut was 25 : 50 : 0 kg N : P_2O_5 : K_2O/ha. Sources of nitrogen and phosphorus were urea and single superphosphate, respectively. The crop was sown on 18th March with seed rate of 100 kg/ha at a spacing of 30 cm x 10 cm. Previous crop was potato (RDF: 275 : 138 : 275 NPK kg/ha) in the field. Recommended package of practice was followed for groundnut crop during the experiment. Yield attributes namely 100 pod weight (g) and 100 kernel weight (g) were recorded after harvest. Pod and haulm yield at harvest from each net plot of size 4.0 m x 2.4 m were recorded and later expressed in q/ha. Shelling per cent was worked out by dividing kernel weight by pod weight and expressed in percentage. Kernel yield was calculated by using formula.

$$\text{Kernel yield (q/ha)} = \frac{\text{Dry pod yield (q/ha)} \times \text{Shelling percentage}}{100}$$

Harvest index (%) was calculated by using formula

$$\text{Harvest index (\%)} = \frac{\text{Pod yield (q/ha)} \times 100}{\text{Pod yield (q/ha) x Haulm yield (q/ha)}}$$

Crop productivity was calculated by using formula

$$\text{Crop productivity (kg/ha/day)} = \frac{\text{Pod yield (kg/ha)}}{\text{Total crop duration (days)}}$$

Total duration of crop was 106 days during the experimentation. Net returns and benefit: cost ratio were calculated by

Net return (₹/ha) = Gross return (₹/ha) - Total cost of cultivation (₹/ha)

Benefit cost ratio (BCR) = Gross return (₹/ha) / Total cost of cultivation (₹/ha)

Return per day was calculated by using formula:

$$\text{Return per day (₹/ha/day)} = \frac{\text{Net return (₹/ha)}}{\text{Total crop duration (days)}}$$

Data were statistically analysed using OPSTAT of CCSHAU, Hisar and interpreted accordingly.

RESULTS AND DISCUSSION

Yield attributes and yields

Perusal of the data (Table 1) revealed that yield attributes *i.e.*, 100 pod weight, 100 kernel weight and shelling percentage, pod, haulm and kernel yields and harvest index were influenced by different varieties of groundnut. Variety GG-20 recorded significantly the highest 100 pod weight (157.64 g) among all varieties. Similarly, the highest 100 kernel weight (57.56 g) was observed under GG-20, which was statistically higher than rest of varieties, except DH 86 (56.47 g). In case of shelling percentage, DH 86 noted statistically the highest value (76.26%) among all treatments. TAG 24 registered the highest pod yield (28.21 q/ha), which was significantly higher than rest of treatments, except DH 86 (26.30 q/ha). Significantly the highest haulm yield (33.45 q/ha) was noted under DH 86 among all varieties. TAG 24 recorded the highest kernel yield (20.39 q/ha) which was statistically at par

with DH 86 (20.09 q/ha), and both were significantly higher than rest of varieties. Despite lower 100 pod and 100 kernel weight, variety TAG 24 recorded higher pod and kernel yields. Priya *et al.*, (2014) also observed similar findings and reported that higher pod yield in TAG-24 was due to its higher number of pegs per plant and total pods per plant. Similarly, TAG 24 had the highest harvest index (32.33%) which was statistically at par with DH 86 (31.80%), and both were significantly higher than rest of varieties. The highest harvest index observed in variety TAG-24 might be due to its compact growth habit and reduced plant height which resulted in lower above ground dry matter production. This result is corroborated by findings of Priya *et al.,* (2016).

A thorough analysis of the data (Table 1) indicated that yield attributes *i.e.,* 100 pod weight and 100 kernel weight, pod, haulm and kernel yields and harvest index varied significant due to different fertility levels. Increase in fertility from to 50% RDF markedly enhanced 100 pod weight and 100 kernel weight. However, the highest values of these characters were noted fewer than 100% RDF. Although shelling percentage was not significantly influenced by different fertility levels, its highest value (74.30%) was recorded fewer than 75% RDF. Increasing dose of fertilizer up to 75% RDF statistically enhanced pod yield, its highest value (26.33 q/ha) was registered under 100% RDF_{NPK}. However, haulm yield responded significantly up to 25% RDF, maximum value (31.83 q/ha) was noted under 75% RDF. In case of kernel yield, subsequent increase in fertility levels up to 75% RDF significantly enhanced kernel yield, its highest value was registered under 100% RDF. Similar trend was also observed in case of harvest index. Application of 100% RDF could have ensured early and plentiful availability of nutrients namely nitrogen and phosphorus to plants which favorably influenced the pod and kernel development, thus improving yield attributes and ultimately realized into higher pod and kernel yields. Similar findings were also reported by Bala *et al.,* (2011).

Crop productivity and Economics

It was evident from Table 2 that crop productivity, gross and net returns, return per day and BCR were markedly influenced by different varieties of groundnut. The highest crop productivity (26.62 kg/ha/day) was noted under TAG 24, which was closely followed by DH 86 (24.80 kg/ha/day) and significantly better than the rest of varieties. The highest gross return (₹ 118.56 x 10^3/ha) and net return (₹ 73.68 x 10^3/ha) were recorded under TAG 24, which was closely followed by DH 86 (₹ 110.40 x 10^3/ha and ₹ 65.51 x 10^3/ha, respectively). Similarly, highest return per day (₹ 695.08/ha/day) and BCR (1.64) were registered with TAG 24, which was closely followed by DH 86 (₹ 618.04/ha/day and 1.46, respectively). Enhanced economic returns and BCR in TAG 24 might be attributed to higher pod and kernel yields with same cost of cultivation as compared to other varieties.

Increasing fertility levels up to 75% RDF markedly increased crop productivity, gross and net return, the highest values were recorded under 100% RDF (24.84 kg/ha/day, ₹ 110.65 x 10^3/ha and ₹ 65.07 x 10^3/ha, respectively) as indicated in Table 2. The highest return per day (₹613.91/ha/day) and BCR (1.43) were observed under 100% RDF which was closely followed by 75% RDF (₹ 557.32/ha/day and 1.31, respectively). Maximum crop productivity and profitability under application of 100% RDF might be due to its significantly higher pod and kernel yields.

CONCLUSION

Based on above findings, it can be concluded that cultivation of TAG 24 and DH 86 with full dose of fertilizers (12.5-25-0 kg N:P_2O_5:K_2O/ha) should be followed during summer season in potato-groundnut cropping system to achieve higher pod and kernel yields along with better crop productivity and economic remuneration. However, there is still scope for reduction in fertilizers dose up to 75% without significantly

affecting yield and economics of summer groundnut in potato-groundnut cropping system. Further, more detailed studies on varieties of groundnut and fertility levels required for drawing a more concrete conclusion and analyze statistically.

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Table 1 Yield attributes, yields and harvest index of groundnut as influenced by different treatments

Treatments	100 pod weight (g)	100 kernel weight (g)	Shelling (%)	Pod yield (q/ha)	Haulm yield (q/ha)	Kernel yield (q/ha)	Harvest index (%)
Varieties							
DH 86	152.13	56.47	76.26	26.30	33.45	20.09	31.80
TAG 24	151.75	53.26	72.08	28.21	31.43	20.39	32.33
TG 37A	141.72	52.93	71.30	22.17	31.10	15.81	28.11
GG 20	157.64	57.56	73.12	16.60	27.60	12.15	25.84
SEm ±	1.48	0.80	0.77	0.71	0.51	0.65	0.62
CD (P=0.05)	5.24	2.83	2.72	2.50	1.80	2.29	2.17
Fertility levels							
No fertilizer	145.71	52.82	71.86	20.32	28.52	14.61	28.00
25% RDF	147.35	53.86	72.72	21.70	30.83	15.83	28.11

50% RDF	151.81	55.49	72.88	23.42	31.50	17.11	29.15
75% RDF	152.63	55.74	74.30	24.83	31.83	18.45	30.64
100% RDF	156.54	57.37	74.20	26.33	31.80	19.55	31.71
SEm ±	2.11	0.79	0.79	0.77	0.50	0.61	0.71
CD (P=0.05)	6.11	2.30	NS	2.22	1.45	1.77	2.06

Table 2 Crop productivity and economics of groundnut as influenced by different treatments

Treatments	Crop productivity (kg/ha/day)	Total cost of cultivation (₹ x 10^3/ha)	Gross return (₹ x 10^3/ha)	Net return (₹ x 10^3/ha)	Return per day (₹/ha/day)	BCR
Varieties						
DH 86	24.80	44.88	110.40	65.51	618.04	1.46
TAG 24	26.62	44.88	118.56	73.70	695.08	1.64
TG 37A	20.91	44.88	93.13	48.25	455.14	1.07
GG 20	15.66	44.88	69.71	24.83	234.19	0.55
SEm ±	0.67		2.98	2.98	28.14	0.07
CD (P=0.05)	2.36		10.52	10.52	99.26	0.23
Fertility levels						
No fertilizer	19.17	44.19	85.35	41.16	388.29	0.93
25% RDF_{NPK}	20.47	44.54	91.07	46.54	439.02	1.04
50% RDF_{NPK}	22.09	44.88	98.36	53.48	504.53	1.19
75% RDF_{NPK}	23.43	45.23	104.31	59.08	557.32	1.31
100% RDF_{NPK}	24.84	45.58	110.65	65.07	613.91	1.43
SEm ±	0.72		3.22	3.22	30.42	0.07
CD (P=0.05)	2.10		9.33	9.33	88.03	0.21

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Effect of different weed management practices on weeds density, yield, nutrient use efficiency, productivity and economics of potato (*Solanum tuberosum* L.)

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ABSTRACT

Field studies were conducted at Potato Research Station, S. D. Agricultural University, Deesa during 2013-14 and 2014-15 to study the effect of different weed management practices on weeds density, yield, nutrient use efficiency, productivity and economics of potato. Results showed that pre-emergence application of metribuzin @ 0.75 kg/ha significantly reduced species-wise and total weed densities. Consequently, markedly higher tuber yield along with improved nutrient use efficiencies, water and crop productivities and net returns were registered under pre-emergence application of metribuzin @ 0.75 kg/ha. Hand weeding at 40 days after planting and weed free till maturity also recorded for significantly higher in tuber yield and profits.

Key words: Economics, potato, productivity, yield, weed density

Potato is an annual crop which plays an important role in human sources of food. Potato tubers are rich in nutrients such as carbohydrates, proteins and amino acids. India is the second largest producer of potato in the world, contributing about 12 per cent of the world's potato production (FAOSTAT, 2016). Weed infestation decrease the quality and quantity of potato tubers via decreasing size, weight and number of tubers (Arnold *et al*., 1997). Due to the long time from sowing to emergence of potato in the fields, and wider spacing among the rows, weeds have enough opportunity for their growth using abundant water and nutrients which directly leads to rapid growth of weeds and decreasing the crop yield from 10% to 80% (Rana *et al*., 2005; Tomar *et al*., 2008). Therefore, weeds must be removed in an appropriate time using suitable herbicide or other weed management practice for achieving optimum yield potato fields. Hence, an experiment was planned to evaluate the effect of different weed management practices on weeds, yield, nutrient use efficiency, productivity and economics of potato.

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MATERIALS AND METHODS

A field experiment was conducted at Potato Research Station, SDAU, Deesa (Gujarat) during *Rabi* seasons of 2013-14 and 2014-15 to study the effect of different weed management practices on weeds, yield, nutrient use efficiency, productivity and economic of potato. The soil was loamy sand in texture, low in organic carbon (0.31%), available nitrogen (170.02 kg/ha), medium in available phosphorus (29.92 kg/ha) and available potassium (297.00 kg/ha). Seven treatments *viz*; weedy check, weed free, hand

weeding (HW) at 30 days and weed free up to maturity, HW at 40 days and weed free up to maturity, HW at 50 days and weed free up to maturity, metribuzin 0.75 kg/ha (pre-emergence) and metribuzin 0.75 kg/ha (post-emergence at 10% plant emergence) were laid out in randomized block design and replicated four times. Recommended dose of fertilizer for potato was 275:140:275 kg N: P_2O_5: K_2O/ha. Potato variety Kufri Badshah was sown on 15th November with seed rate of 3000 kg/ha at a spacing of 50 cm x 20 cm. Recommended package of practice were followed for potato crop during the experiment. Weed density was counted at 50 days at planting (DAP) by using 0.5 m x 0.5 m quadrant from plot which was further classified into different species i.e; grasses, broadleaf weeds (BLW) and total weeds and later expressed in terms of number per m^2. Total tuber yield at harvest from each net plot of size 3.0 m x 4.0 m was further classified into different grades *i.e*, 0-25 g, 25-50 g, 50-75 g and >75 g and later expressed in t/ha. Weed index (%), crop productivity (kg/ha/day), water productivity (kg/ha/mm) and Nutrient use efficiency of N, P and K (kg tuber/kg nutrient applied) were calculated by using standard formula. Total duration of crop was 97 days during all the years of experimentation and the total amount of irrigation water used in irrigation was 700 mm.

Weed density data were subjected to square root transformation before statistically analysis. Data were statistically analysed using OPSTAT of CCSHAU, Hisar and interpreted accordingly.

RESULTS AND DISCUSSION

Weed densities and tuber yields

Perusal of the data (Table 1) revealed that weed densities in potato were significantly influenced by different weed management practices. Both pre-emergence and post-emergence application of metribuzin 0.75 kg/ha recorded significant reduction in densities of BLW (0.77/m^2) and grasses (0.43/m^2) and total weed (1.2/m^2). All grade-wise tuber yields and total tuber yield except 0-25 g tuber yield were significantly varied by various treatments (Table 1). Significantly highest 25-50 g grade tuber yield (5.31 t/ha) was registered under pre-emergence application of metribuzin 0.75 kg/ha which significantly higher than weed free at 30 days and weed free up to maturity and HW at 50 days and weed free up to maturity and metribuzin 0.75 kg/ha (Post-emergence). Pre-emergence application of metribuzin 0.75 kg/ha markedly increased 50-75 g (13.49 t/ha) and >75 g (10.54 t/ha) grade tuber yield, which was 48.24 % and 21.0% higher than weedy check, respectively. In case of total tuber yield, weed free check recorded significantly higher tuber yield (33.10 t/ha), however pre-emergence application of metribuzin 0.75 kg/ha had statistically higher yield (31.52 t/ha) than weedy check and post-emergence application of metribuzin 0.75 kg/ha, which was at the tune of 30.08% and 12.45%, respectively. Yield reduction due to weeds (WI) among all weed management practices was lowest under pre-emergence application of metribuzin 0.75 kg/ha (5.01%). This was due to lower weed infestation under pre-emergence application of metribuzin which resulted in better crop growth with lower crop-weed competition for nutrients and water. Improved growth and development of crop under this treatment later translated into higher tuber yield, which was corroborated by findings of Kumar *et al.* (1998), Mukherjee *et al.* (2012) and Zarzecka *et al.* (2004).

NUE, productivities and economics

It was evident from Table 2 that NUE and productivities were varied significantly due to different treatments. Pre-emergence application of metribuzin 0.75 kg/ha recorded markedly higher NUE of N (114.61 kg tuber per kg N applied), P (225.12 kg tuber per kg N applied) and K (114.61 kg tuber per kg N applied) over rest of weed management practices, except HW at 50 days and weed free up to maturity. Similarly, water (71.25 kg/ha/mm) and crop (324.91 kg/ha/day) productivities of potato were significantly increased under pre-emergence

application of metribuzin 0.75 kg/ha over weedy check and post-emergence application of metribuzin 0.75 kg/ha. This was attributed to lower crop-weed competition which resulted in better utilization of nutrients and water and ultimately realized into enhanced growth and yield of crop under pre-emergence application of metribuzin 0.75 kg/ha.

Highest net return was recorded under weed free (₹ 71.48 x 10^3/ha) which was closely followed by pre-emergence application of metribuzin 0.75 kg/ha (₹ 71.25 x 10^3/ha) and HW at 40 days and weed free up to maturity (₹ 63.06 x 10^3/ha). Similarly, weed free had highest return per day (₹ 736.90 /ha/day) which was statistically at par with pre-emergence application of metribuzin 0.75 kg/ha (₹ 734.54 / ha / day) which was followed by HW at 40 days and weed free up to maturity (₹ 650.13/ha/day). However, in case of BCR, pre-emergence application of metribuzin 0.75 kg/ha had highest value of BCR (0.83), which was closely followed by weed free (0.76) and HW at 40 days and weed free up to maturity (0.71). The reason behind higher profitability in pre-emergence application of metribuzin 0.75 kg/ha was higher tuber yield, which increased economic returns and BCR.

CONCLUSION

Based on above findings, it can be concluded that application of Metribuzin 0.75 kg/ha as pre-emergence herbicide can be followed to achieve higher tuber yield and profitability in potato along with efficient utilization of irrigation water and nutrients. In case of higher labour availability, hand weeding can be started from 40 days after planting and keep weed free till maturity for higher tuber yield and economic remuneration.

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Table1 Weed density, tuber yields and WI as influenced by different weed management practices in potato (Pooled data of two years)

Treatment	Weed density (No./ m^2) at 50 DAP			Grade-wise tuber yield (t/ha)					WI (%)
	BLW	Grasses	Total	0-25 g	25-50 g	50-75 g	>75 g	Total	
Weedy check	2.12 (4.03)	1.63 (2.17)	2.58 (6.20)	2.20	4.23	9.10	8.71	24.23	26.80
Weed free	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	1.94	5.14	13.87	12.15	33.10	0.00
HW at 30 days and weed free up to maturity	1.55 (1.93)	1.01 (0.52)	1.71 (2.44)	1.77	3.91	12.41	11.20	29.29	11.51
HW at 40 days and weed free up to maturity	1.73 (2.52)	1.09 (0.70)	1.92 (3.22)	2.08	4.90	12.85	10.58	30.41	8.13
HW at 50 days and weed free up to maturity	1.76 (2.60)	1.46 (1.63)	2.18 (4.23)	1.75	3.56	12.57	11.47	29.35	11.33
Metribuzin 0.75 kg/ha (pre-emergence)	1.12 (0.77)	0.96 (0.43)	1.30 (1.20)	2.18	5.31	13.49	10.54	31.52	5.01
Metribuzin 0.75 kg/ha (post-emergence)	1.28 (1.15)	0.98 (0.46)	1.44 (1.60)	1.85	4.22	11.62	10.34	28.03	15.32
SEd±	0.09	0.04	0.12	0.19	0.56	0.91	0.93	1.42	
CD (P=0.05)	0.26	0.11	0.26	NS	1.19	1.94	1.96	3.00	

*Figures in parentheses are original values

Table 2 NUE, water and crop productivities and economics as influenced by different weed management practices in potato (Pooled data of two years)

Treatment	NUE (kg tuber per kg nutrient applied)			Water productivity (kg/ha/mm)	Crop productivity (kg/ha/day)	Net return (₹ x 10^3/ha)	Return per day (₹/ha/day)	BCR
	N	P	K					
Weedy check	88.12	173.10	88.12	34.17	249.83	34.17	352.23	0.39
Weed free	120.35	236.40	120.35	71.48	341.19	71.48	736.90	0.76
HW at 30 days and weed free up to maturity	106.53	209.25	106.53	55.47	302.01	55.47	571.90	0.61
HW at 40 days and weed free up to maturity	110.59	217.23	110.59	63.06	313.53	63.06	650.13	0.71
HW at 50 days and weed free up to maturity	106.74	209.67	106.74	53.77	302.62	53.77	554.34	0.58
Metribuzin 0.75 kg/ha (pre-emergence)	114.61	225.12	114.61	71.25	324.91	71.25	734.54	0.83
Metribuzin 0.75 kg/ha (post-emergence)	101.94	200.23	101.94	53.83	288.99	53.83	554.93	0.62
SEd±	5.15	10.11	5.15	7.08	14.59	7.08	72.96	0.08
CD (P=0.05)	10.90	21.41	10.90	14.98	30.90	14.98	154.48	0.17

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Heterosis for seed yield and its components in Indian mustard (*Brassica juncea* L. Czern & Coss.)

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ABSTRACT

Brassica juncea L. is an important oilseed crop, which occupies premier position in Indian agriculture. Developing high yielding genotypes has been a major breeding objective in Indian mustard. Present study was conducted at Castor-Mustard research station, S. D. Agricultural University, Sardarkrushinagar during *Rabi* 2016-17 to determine heterosis of 45 crosses of Indian mustard. Parents and F_1 hybrids were evaluated in RBD with three replications. The heterosis was observed amongst the best crosses identified on the basis of SCA effects. Hybrids RS 1134 x GM 2, RH 119 x GM 2,RS 1 x GM 2, RH 119 x Urvashi and Urvashi x GM 2 exhibited highest magnitude of heterosis with higher per se performance for seed yield, respectively. The high yielding crosses may be exploited for developing superior genotypes and the parents involved may be converted to well adapted cytoplasmic male sterile or restorer lines.

Key words: Heterosis, Seed yield and Indian mustard

Oilseed Brassicas, also known as rapeseed mustard, have a significant role in Indian agriculture since almost each part of the plant is consumed either by human beings or animals depending upon the crop and its growth stage. Rapeseed-mustard crops in India include toria (*Brassica campestris* L. var. toria), brown sarson (*B. campestris* L. brown sarson), yellow sarson (*B. campestris* L. var. yellow sarson), Indian mustard (*B. juncea* L. Czernand Coss), black mustard (*B. nigra*) and taramira (*Eruca sativa/vesicara* Mill.) species. These species have been grown traditionally since about 3,500 BC along with non-traditional species like gobhi saraon (*B. napus* L.) and karan rai (*B. carinata* A. Braun). Among them, Indian mustard is an important oilseed crop of the Indian subcontinent and contributes more than 80% of the total rapeseed-mustard production of the country. It is the second important oilseed crop after soyabean at national level and contributes nearly 27% of edible oil pool of the country. There is wider yield gap when productivity of India is compared with countries like Germany (4.3 tons/ha), France (3.8 tons/ha) and UK (3.4 ton/ha). There is compelling need to increase and stabilize the productivity of Indian mustard. This can be achieved through effective utilization of germplasm resources and integration of genomic tools to impart efficiency and pace of breeding processes (Banga, 2012). Exploitation of heterosis may play a very significant role in boosting up the production and productivity of Indian mustard and for breaking the present yield barrier. Comprehensive analysis of the combining ability involved in the inheritance of quantitative traits and in the phenomenon of heterosis is necessary for evaluation of various breeding procedures (Allard, 1960). Availability

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of effective means of hybrid seed production led to the development of few commercial hybrids in India during last decade (Kumar *et al*., 2012); however, the level of yield gain achieved from these hybrids is marginal.

MATERIALS AND METHODS

The study was conducted at Castor-Mustard Research Station, S. D. Agricultural University, Sardarkrushinagar (Gujarat) during *Rabi* 2016-17. The experimental material consisted of 45 F_1's hybrids of Indian mustard (*B. juncea*) involving 10 parents and one check GDM 4. The ten parental genotypes were crossed in half diallel fashion to generate 45 F_1's hybrids (crosses). The crosses along with their parents were planted in randomized block design with three replications. The treatments were raised in rows of 3 m length with a distance of 45 cm between rows and 15 cm between plants, where each treatment was represented by a single row. Standard agronomic practices were followed to raise the good crop. Observations were recorded on randomly selected five competitive plants for ten quantitative traits, *viz*., days to flowering, days to maturity, plant height (cm), length of main branch (cm), branches per plant, number of siliquae on main branch, number siliquae per plant, length of siliquae (cm), seeds per siliquae and seed yield per plant (g).

RESULTS AND DISCUSSION

The variation due to parents *vs.* crosses was highly significant for all the characters under study except plant height (cm), number of siliquae on main branch and length of siliquae suggesting the presence of heterosis for these traits in the series of crosses. Similarly, highly significant variance due to crosses revealed that the sufficient amount of genetic variability was generated in the hybrids. The estimates of mid parent, better parent and standard heterosis for all the characters under study are presented in Table 2.Heterosis for days to flowering was estimated over earlier flowering parent of the hybrids. Hence crosses with negative heterosis were considered as desirable. Manifestation of heterosis was found in both positive and negative directions. The extent of heterosis over standard check ranged from -13.95 (Kranti x P.Vijay) to 6.98 (RH 1134 x Navgold) and for better parents ranged from -15.60 (RH 1134 x Kranti) to -2.13 (RH 1134 x Navgold) for days to flowering. The negative heterosis over better parent estimates was considered desirable for days to maturity. The heterosis for this character ranged from -6.06 (RH 119 x Kranti) to 2.20 (RH 1134 x GM 2) over standard check and for better parent heterosis ranged from -5.74 (Kranti x GM 2) to 1.69 (Urvashi x Kranti). From these consideration the cross Kranti x P.Vijay and RH 119 x Kranti were found earliest. There are twenty five crosses exhibited significant and negative heterosis over standard check as considered for early maturity. Standard heterosis for the plant height ranged from -11.66 (P.Vijay x Navgold) to 22.70 (RH 1134 x RS 1). Only one cross namely, P.Vijay x Navgold and P.Vijay xGM 2 revealed negative and significant heterosis over mid parent, better parent and standard check for dwarf type plant. The extent of heterosis over standard check for length of main branch ranged from -4.71 (P.Vijay x GM 2) to 15.88 (RH 119 x Urvashi). Eighteen crosses exhibited significant and positive heterosis over standard check as considered for length of main branch and none of the crosses exhibited negative significant heterosis over standard check for length of main branch. While for heterosis over better parent only three crosses exhibited significant and positive heterosis and range of this character from -13.16 (Navgold x RS 1) to 19.51 (Kranti x Navgold). The attribute branches per plant ranged from -14.50 (RH 1134 x RS 1) to 187.50 (RH 119 x GM 2) and the nineteen hybrids exhibited significant and positive heterosis over standard check. While none of the crosses expressed negative

significant heterosis over standard check. For over better parent heterosis nine crosses expressed negative significant heterosis and sixteen crosses expressed positive and significant heterosis.

Heterosis response over better parent for number of siliquae on main branch ranged from -40.74 (Urvashi x Navgold) to 16.92 (Kranti x Navgold) and over standard check ranged from -35.85 (Urvashi x Navgold) to 26.13 (Urvashi x P.Vijay). Positive and significant standard heterosis for number of siliquae on main branch was recorded in the twenty nine crosses combinations and only one cross showed significant negative heterosis. While five crosses expressed significant and negative heterosis and only three crosses expressed significant and positive heterosis over better parents for number of siliquae on main branch. The best heterotic response for number of siliquae per plant was noted in hybrids (RH 119 x Urvashi, RH 119 x Kranti, RH 119 x Navgold, RH 119 x GM 1, RH 119 x GM 2, Urvashi x P.Vijay, Urvashi x Navgold, Urvashi x GM 2, RH 1134 x P.Vijay, Kranti x P.Vijay, Kranti x Navgold, Kranti x GM 2, P.Vijay x Navgold, P.Vijay x GM 1 and RH 749 x Navgold) respectively, over their respective standard check. While, none of the parent was found negative and significant for this trait over MP, BP and SH. Standard heterosis for length of siliquae ranged from -1.22 (RS 1 x GM 1) to 41.87 (Navgold x RS 1). The sixteen crosses exhibited significant positive heterosis over standard check GDM 4 for the character length of siliquae. While none of the parent was found negative and significant for this trait over better parent and standard check. Out of forty five cross combinations, only fifteen crosses were found significant and positive heterosis over standard check (GDM 4) for number of seeds per siliquae. While two crosses revealed significant and negative heterosis over standard check (GDM 4) for number of seeds per siliquae.For the traits seed yield per plant, standard heterosis ranged from 9.37 (Navgold x RS 1) to 181.25 (RH 1134 x GM 2) and better parent ranged from -51.78 (P.Vijay x GM 1)to 147.71 (RH 1134 x GM 2) and out of forty five cross combination there was thirty nine crosses show significant and positive standard heterosis over check GDM 4. While none of the crosses show significant negative standard heterosis for seed yield per plant. On the basis of overall study of heterosis the best crosses were Kranti x P. Vijay for days to flowering, RH 119 x Kranti for days to maturity, P. Vijay x Navgold for plant height, RH 119 x Urvashi for length of main branch, RH 119 x GM 2 for number of branches per plant and number of siliquae per plant, Urvashi x P. Vijay for number of siliquae on main branch,Navgold x RS 1 for length of siliquae, RH 119 x RH 1134 for seeds per siliquae and RH 1134 x GM 2 for seed yield per plant. A wide range of positive heterosis for length of siliquae and seed yield per plant was reported by Rawat (1975). Similarly, significant positive heterosis for seed yield and component traits in Indian mustard were reported by many workers (Banga and Labana, 1984; Hirve and Tiwari, 1992; Aher *et al*., 2009; Verma *et al*., 2011) using different sets of materials. All the hybrids may prove to be the best sources for tracking down the better recombinants for yield and important contributing traits. The high yielding cross combination can further be exploited for their commercial utilization and the parents involved in developing heterotic hybrids in the present study shall be converted to well adapted cytoplasmic male sterile or restorer lines. These results are similar in agreement with earlier reported by Chauhan *et al*., (2000), Kumar *et al*., (2002), Singh *et al*., (2003), Singh *et al*., (2007), Singh *et al*., (2009), Gupta *et al*., (2010), Verma *et al*., (2011), Saeed *et al*., (2013). It clearly demonstrates the scope of improving the productivity of Indian mustard through genetic manipulations.

CONCLUSION

The best heterotic response for yield and other yield contributing traits exhibited a reasonable

and significantly increase over mid, better and standard parents. These cross combinations in order of merit were RS 1134 x GM 2, RH 119 x GM 2, RS 1 x GM 2, RH 119 x Urvashi and Urvashi x GM 2 suggested that these individual hybrids may be used in heterosis breeding programme for improvement in seed yield. On the basis of computed genetic parameters simple selection or pedigree method of breeding with inter mating in early segregating generation has been suggested for the exploitation of additive genetic variance for the simultaneous exploitation of both additive and non-additive gene action and breeding method such as biparental mating was suggested.

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Table 1 Analysis of variance (mean squares) for various characters in Indian mustard

Source of variation	d.f.	Days to flowering	Days to maturity	Plant height (cm)	Length of main branch (cm)	Branches per plant
Replications	2	0.17	143.77**	483.75*	8.41	203.01**
Genotypes (G)	54	14.71**	17.71**	338.79**	78.51**	158.03**
Parents (P)	9	18.8**	10.23*	480.30**	122.37**	252.69**
Hybrids (H)	44	11.69**	18.16**	316.96**	64.38**	118.33**
Parents vs. Hybrids	1	110.94**	65.19**	26.21	305.16**	1052.93**
Error	108	1.75	3.99	139.18	23.73	16.71
Total :-	164	5.99	10.21	209.11	41.58	65.50

Source of variation	d.f.	Number of silique on main branch	Number silique per plant	Length of silique	Seeds per silique	Yield per plant (g)
Replications	2	74.50**	53165.09**	0.69	4.32**	370.72**
Genotypes (G)	54	46.51**	11671.22**	1.47**	1.85**	467.96**
Parents (P)	9	56.35**	3190.92	0.12	1.39**	779.07**
Hybrids (H)	44	44.32**	6673.81**	1.73815**	1.84941**	295.74**
Parents vs. Hybrids	1	54.35	307879.8**	1.86	5.95**	5245.39**
Error	108	13.33	3042.91	0.51	0.37	59.53
Total :-	164	25.00	6495.19	0.83	0.91	197.81

Table 2: Estimates of per cent heterosis over mid parent (MP), better parent (BP) and check variety (GDM 4) for the characters under study

Sr. No.	Name of Cross	Days to lowering			Days to maturity		
		MP	BP	SH	MP	BP	SH
1	RH 119 x Urvashi	-10.87 **	-10.87 **	-4.65*	-2.11	-2.52	-4.13**
2	RH 119 x RH 1134	-5.38 **	-6.38 **	2.33	-2.1	-2.24	-3.86*
3	RH 119 x Kranti	-7.39 **	-13.77 **	-7.75**	-3.67 **	-4.48 **	-6.06**
4	RH 119 x P.Vijay	2.33	-4.35	2.33	-2.09	-2.5	-3.31*
5	RH 119 x RH 749	-2.22	-4.35	2.33	-2.26	-3.08 *	-4.68**
6	RH 119 x Navgold	-7.35 **	-8.70 **	-2.33	-2.77 *	-3.84 **	-3.31*
7	RH 119 x RS 1	-1.5	-5.07 *	1.55	1.39	0.55	0.55
8	RH 119 x GM 1	-9.09 **	-13.04 **	-6.98**	0.14	-0.28	-1.93
9	RH 119 x GM 2	-5.19 *	-7.25 **	-0.78	-0.69	-1.91	-1.10
10	Urvashi x RH 1134	-3.23	-4.26	4.65	-1.13	-1.4	-3.31*
11	Urvashi x Kranti	-5.84 **	-12.32 **	-6.20**	2.13	1.69	-0.83
12	Urvashi x P.Vijay	-2.33	-8.70 **	-2.33	2.52 *	1.67	0.83
13	Urvashi x RH 749	-5.19 *	-7.25 **	-0.78	0.71	0.28	-2.20
14	Urvashi x Navgold	-7.35 **	-8.70 **	-2.33	-2.36	-3.84 **	-3.31*
15	Urvashi x RS 1	-6.02 **	-9.42 **	-3.10	-3.77 **	-4.96 **	-4.96**
16	Urvashi x GM 1	-4.55 *	-8.70 **	-2.33	-3.39 **	-3.39 *	-5.79**
17	Urvashi x GM 2	-10.37 **	-12.32 **	-6.20**	-2.78 *	-4.37 **	-3.58*
18	RH 1134 x Kranti	-8.46 **	-15.60 **	-7.75**	-3.25 **	-3.93 **	-5.79**
19	RH 1134 x P.Vijay	-3.45	-10.64 **	-2.33	-1.96	-2.5	-3.31*
20	RH 1134 x RH 749	-7.69 **	-10.64 **	-2.33	0.42	-0.28	-2.20
21	RH 1134 x Navgold	0.36	-2.13	6.98*	2.36	1.1	1.65
22	RH 1134 x RS 1	1.86	-2.84	6.20*	0.14	-0.83	-0.83
23	RH 1134 x GM 1	-4.87 *	-9.93 **	-1.55	1.41	1.12	-0.83
24	RH 1134 x GM 2	-2.56	-5.67 *	3.10	2.77 *	1.37	2.20
25	Kranti x P.Vijay	-7.11 **	-7.50 **	-13.95**	-1.27	-2.5	-3.31*
26	Kranti x RH 749	0.4	-4.55	-2.33	0	0	-3.31*
27	Kranti x Navgold	-2.77	-8.21 **	-4.65*	-1.96	-3.84 **	-3.31*
28	Kranti x RS 1	-3.64	-7.03 **	-7.75**	-3.64 **	-5.23 **	-5.23**
29	Kranti x GM 1	-5.31 *	-7.94 **	-10.08**	-2.98 *	-3.39 *	-5.79**

30	Kranti x GM 2	-8.37 **	-12.88 **	-10.85**	-3.77 **	-5.74 **	-4.96**
31	P.Vijay x RH 749	-4.76 *	-9.09 **	-6.98**	-0.42	-1.67	-2.48
32	P.Vijay x Navgold	-5.51 *	-10.45 **	-6.98**	-4.83 **	-5.48 **	-4.96**
33	P.Vijay x RS 1	-4.03	-7.03 **	-7.75**	-2.90 *	-3.31 *	-3.31**
34	P.Vijay x GM 1	0	-2.38	-4.65*	0	-0.83	-1.65
35	P.Vijay x GM 2	-4.76 *	-9.09 **	-6.98**	-1.1	-1.91	-1.10
36	RH 749 x Navgold	-9.77 **	-10.45 **	-6.98**	-3.35 **	-5.21 **	-4.68**
37	RH 749 x RS 1	-9.23 **	-10.61 **	-8.53**	-3.36 **	-4.96 **	-4.96**
38	RH 749 x GM 1	-9.30 **	-11.36 **	-9.30**	-1.7	-2.12	-4.55**
39	RH 749 x GM 2	-5.30 *	-5.30 *	-3.10	-2.09	-4.10 **	-3.31*
40	Navgold x RS 1	-1.53	-3.73	0.00	-1.37	-1.64	-1.10
41	Navgold x GM 1	-0.77	-3.73	0.00	-2.36	-3.84 **	-3.31*
42	Navgold x GM 2	-9.77 **	-10.45 **	-6.98**	-1.5	-1.64	-0.83
43	RS 1 x GM 1	-3.15	-3.91	-4.65*	-0.98	-2.2	-2.20
44	RS 1 x GM 2	-3.08	-4.55	-2.33	-1.51	-1.91	-1.10
45	GM 1 x GM 2	-4.65 *	-6.82 **	-4.65*	0	-1.64	-0.83
	Max	2.33	-2.13	6.98	2.77	1.69	2.20
	Min	-10.87	-15.60	-13.95	-4.83	-5.74	-6.06

Table 2: Continued…

Sr. No.	Name of Cross	Plant height(cm)			Length of main branch (cm)		
		MP	BP	SH	MP	BP	SH
1	RH 119 x Urvashi	-6.29	-9.88 *	11.96*	10.67 **	5.91	15.88**
2	RH 119 x RH 1134	-4.46	-7.41	15.03**	0.55	-2.15	7.06*
3	RH 119 x Kranti	-6.37	-12.84 **	8.28	6.02	-5.38	3.53
4	RH 119 x P.Vijay	-3.34	-7.16	15.34**	-2.02	-8.6	0.00
5	RH 119 x RH 749	2.84	-1.48	22.39**	-1.09	-2.69	6.47
6	RH 119 x Navgold	-2.93	-10.12 *	11.66*	-1.14	-6.99	1.76
7	RH 119 x RS 1	-6.65	-8.15	14.11**	-6.38	-7.37	3.53
8	RH 119 x GM 1	-4.43	-9.38	12.58**	-1.69	-5.91	2.94
9	RH 119 x GM 2	-1.53	-12.35 *	8.90	-8.08 *	-11.29 **	-2.94
10	Urvashi x RH 1134	4.77	3.95	21.17**	6.36	4.55	8.24*
11	Urvashi x Kranti	-4.84	-8.02	5.52	4.43	-2.94	-2.94
12	Urvashi x P.Vijay	0.67	0.53	15.34**	10.57 *	7.65	7.65*
13	Urvashi x RH 749	3.62	3.21	18.40**	4	1.11	7.06*
14	Urvashi x Navgold	5.98	1.87	16.87**	12.57 **	10.59 *	10.59**
15	Urvashi x RS 1	-5.48	-7.65	11.04*	6.67	1.05	12.94**
16	Urvashi x GM 1	-11.26 *	-12.57 *	0.31	4.12	4.12	4.12
17	Urvashi x GM 2	4.64	-3.48	10.74	4.96	4.05	5.88
18	RH 1134 x Kranti	-6.45	-10.26 *	4.60	6.21	-2.84	0.59
19	RH 1134 x P.Vijay	-1.46	-2.37	13.80**	5.64	1.14	4.71
20	RH 1134 x RH 749	0.67	-0.53	15.95**	-5.06	-6.11	-0.59
21	RH 1134 x Navgold	2.34	-2.37	13.80**	2.94	-0.57	2.94
22	RH 1134 x RS 1	3.63	2.04	22.70**	3.28	-0.53	11.18**
23	RH 1134 x GM 1	1.21	-1.05	15.34**	-4.43	-6.06	-2.75
24	RH 1134 x GM 2	8.05	-1.05	15.34**	6.02	5.11	8.82*
25	Kranti x P.Vijay	-0.83	-4.02	9.82	16.61 **	11.18 *	5.29
26	Kranti x RH 749	2.78	-0.27	13.50**	14.11 **	3.33	9.41*
27	Kranti x Navgold	5.48	4.87	12.27**	26.45 **	19.51 **	15.29**
28	Kranti x RS 1	-9.58 *	-14.54 **	2.76	16.07 **	2.63	14.71**
29	Kranti x GM 1	-1.69	-3.58	7.36	12.66 **	4.71	4.71
30	Kranti x GM 2	13.08 *	7.74	15.34**	15.36 **	6.36	8.24*

31	P.Vijay x RH 749	2.42	2.14	16.87**	10.85 **	5	11.18**
32	P.Vijay x Navgold	-19.78 **	-22.79 **	-11.66*	7.08	6.1	2.35
33	P.Vijay x RS 1	-5.36	-7.65	11.04*	-0.28	-7.89	2.94
34	P.Vijay x GM 1	-1.36	-2.68	11.35*	2.11	-0.59	-0.59
35	P.Vijay x GM 2	-7.4	-14.48 **	-2.15	-2.99	-6.36	-4.71
36	RH 749 x Navgold	5.59	1.89	15.95**	4.07	-0.56	5.29
37	RH 749 x RS 1	-3.54	-6.12	12.88**	4.32	1.58	13.53**
38	RH 749 x GM 1	0	-1.08	12.58**	5.14	2.22	8.24*
39	RH 749 x GM 2	10.63 *	2.43	16.56**	6.52	4.44	10.59**
40	Navgold x RS 1	-3.66	-9.44	8.90	-6.78	-13.16 **	-2.94
41	Navgold x GM 1	5.65	3.03	14.72**	-0.6	-2.35	-2.35
42	Navgold x GM 2	8.32	3.77	9.82	-2.08	-4.62	-2.94
43	RS 1 x GM 1	-8.87	-12.24 *	5.52	-2.22	-7.37	3.53
44	RS 1 x GM 2	7.91	-2.55	17.18**	1.93	-2.63	8.82*
45	GM 1 x GM 2	8.39	1.38	12.88**	0.87	0	1.76
	Max	13.08	7.74	22.70	26.45	19.51	15.88
	Min	-19.78	-22.79	-11.66	-8.08	-13.16	-4.71

Table 2: Continued…

Sr. No.	Name of Cross	Branches per plant			Number of silique on main branch		
		MP	BP	SH	MP	BP	SH
1	RH 119 x Urvashi	83.51 **	76.82 **	33.50**	3.26	-2.46	18.75**
2	RH 119 x RH 1134	96.94 **	77.37 **	-0.25	-18.46 **	-20.64 **	-3.38
3	RH 119 x Kranti	-25.00 *	-49.54 **	10.25	7.42	-7.8	12.25**
4	RH 119 x P.Vijay	51.16 **	50.66 *	14.50	3.17	-6.37	14.00**
5	RH 119 x RH 749	37.34 *	31.52	8.50	-2.61	-8.01	12.00**
6	RH 119 x Navgold	38.18 *	27.37	14.00	-1.25	-11.09	8.25
7	RH 119 x RS 1	41.77 *	31.36	16.25	-1.66	-2.67	18.50**
8	RH 119 x GM 1	65.59 **	32.21 *	67.25	0.57	-9.03	10.75*
9	RH 119 x GM 2	243.28 **	212.50 **	187.50**	3.67	-1.44	20.00**
10	Urvashi x RH 1134	80.84 **	68.57 **	18.00	5.82	2.6	18.25**
11	Urvashi x Kranti	17.74	-22.27 **	69.50**	6.65	-3.7	4.25
12	Urvashi x P.Vijay	74.32 **	67.43 **	27.25	21.57 **	16.51 *	26.13**
13	Urvashi x RH 749	72.46 **	59.39 **	31.50**	3.46	3.46	12.00**
14	Urvashi x Navgold	30.41	16.2	4.00	-37.64 **	-40.74 **	-35.85**
15	Urvashi x RS 1	29.97	16.38	3.00	1.32	-3.35	15.25**
16	Urvashi x GM 1	-2.29	-24.11	-4.00	5.44	0.69	9.00
17	Urvashi x GM 2	38.27 *	21.74	12.00	6.65	5.92	16.25**
18	RH 1134 x Kranti	-20.43	-49.20 **	11.00	1.48	-10.85	2.75
19	RH 1134 x P.Vijay	109.16 **	87.83 **	42.75**	7.58	0.11	15.38**
20	RH 1134 x RH 749	42.66 *	23.64	2.00	-2.91	-5.86	8.50
21	RH 1134 x Navgold	112.00 **	77.65 **	59.00**	4	-4.01	10.63*
22	RH 1134 x RS 1	14.77	-3.39	-14.50	-3.41	-5.03	13.25**
23	RH 1134 x GM 1	75.22 **	29.51 *	63.83**	-6.82	-13.59 *	-0.42
24	RH 1134 x GM 2	51.80 **	25.82	15.75	-6.07	-8.32	5.67
25	Kranti x P.Vijay	-7.08	-37.38 **	36.83**	20.91 **	13.6	12.75**
26	Kranti x RH 749	-22.92 *	-46.91 **	16.00	22.76 **	10.85	20.00**
27	Kranti x Navgold	6.49	-24.94 **	64.00**	23.41 **	16.92 *	14.00**
28	Kranti x RS 1	-16.45	-41.30 **	28.25	6.66	-7.65	10.13*
29	Kranti x GM 1	-24.35 **	-40.27 **	30.50*	23.82 **	16.75 *	15.00**

30	Kranti x GM 2	-1.29	-29.86 **	53.25**	16.75 *	4.78	15.00**
31	P.Vijay x RH 749	78.23 **	71.21 **	41.25**	5.3	0.92	9.25
32	P.Vijay x Navgold	68.28 **	55.59 **	39.25**	12.71	11.71	10.88**
33	P.Vijay x RS 1	43.16 *	33.05	17.75	-2.29	-10.48	6.75
34	P. Vijay x GM 1	35.80 *	8.7	37.50**	1.39	1.01	0.25
35	P. Vijay x GM 2	26.19	15.22	6.00	5.26	0.23	10.00*
36	RH 749 x Navgold	83.72 **	76.54 **	58.00**	10.57	5.08	13.75**
37	RH 749 x RS 1	26.9	22.6	8.50	7.47	2.52	22.25**
38	RH 749 x GM 1	28.23 *	5.93	34.00**	11.25	6.24	15.00**
39	RH 749 x GM 2	30.66	23.91	14.00	10.44	9.68	20.38**
40	Navgold x RS 1	27.25	26.54	13.25	-6.81	-15.30 *	1.00
41	Navgold x GM 1	22.45	4.55	32.25**	14.41 *	13.83	12.13*
42	Navgold x GM 2	57.02 **	54.89 **	42.50**	-4.22	-9.57	-0.75
43	RS 1 x GM 1	1.4	-13.83	9.00	2.18	-6.71	11.25*
44	RS 1 x GM 2	41.83 *	39.13 *	28.00	-10.59	-14.15 *	2.38
45	GM 1 x GM 2	32.04 *	14.03	44.25**	2.16	-3.08	6.37
	Max	243.28	212.50	187.50	23.82	16.92	26.13
	Min	-25.00	-49.54	-14.50	-37.64	-40.74	-35.85

Table 2: Continued…

Sr. No.	Name of Cross	Number of siliquae per plant			Length of siliqua (cm)		
		MP	BP	SH	MP	BP	SH
1	RH 119 x Urvashi	98.09 **	94.50 **	55.78**	-1.75	-4.55	2.44
2	RH 119 x RH 1134	26.73	26.7	-2.20	8.57	7.95	15.85**
3	RH 119 x Kranti	58.46 **	48.83 **	30.78*	4.65	2.27	9.76*
4	RH 119 x P.Vijay	55.83 **	47.64 **	27.34	12.79	10.23	18.29**
5	RH 119 x RH 749	38.31 **	22.69	22.34	20.66	16.81	33.90**
6	RH 119 x Navgold	53.11 **	35.91 *	35.31*	8.57	7.95	15.85*
7	RH 119 x RS 1	36.61 **	20.62	21.56	0	-2.27	4.88
8	RH 119 x GM 1	57.26 **	37.99 **	41.09**	1.73	0	7.32
9	RH 119 x GM 2	99.17 **	79.24 **	72.97**	13.12	6.82	14.63*
10	Urvashi x RH 1134	58.59 **	55.68 **	24.69	10.59	8.05	14.63*
11	Urvashi x Kranti	50.33 **	43.67 **	26.25	1.8	1.19	3.66
12	Urvashi x P.Vijay	57.86 **	52.23 **	31.30*	8.98	8.33	10.98*
13	Urvashi x RH 749	42.68 **	28.64 *	28.28	16.38	9.57	25.61**
14	Urvashi x Navgold	45.42 **	31.20 *	30.63*	5.88	3.45	9.76*
15	Urvashi x RS 1	35.18 *	21.3	22.25	-0.6	-1.19	1.22
16	Urvashi x GM 1	21.23	8.1	10.53	2.38	1.18	4.88
17	Urvashi x GM 2	49.00 **	36.33 *	31.56*	6.7	3.61	4.88
18	RH 1134 x Kranti	52.05 **	42.78 **	25.47	5.26	3.45	9.76*
19	RH 1134 x P.Vijay	71.03 **	62.01 **	39.73*	10.29	8.39	15.00*
20	RH 1134 x RH 749	24.91	10.78	10.47	-4.97	-8.51	4.88
21	RH 1134 x Navgold	42.18 **	26.18	25.63	-4.6	-4.6	1.22
22	RH 1134 x RS 1	17.67	3.88	4.69	-1.75	-3.45	2.44
23	RH 1134 x GM 1	26.46	10.94	13.44	-4.65	-5.75	0.00
24	RH 1134 x GM 2	23.99	11.56	7.66	0.48	-4.6	1.22
25	Kranti x P.Vijay	57.57 **	56.12 **	37.19*	1.19	1.19	3.66
26	Kranti x RH 749	29.27 *	21.59	21.25	6.74	1.06	15.85*
27	Kranti x Navgold	72.56 **	62.43 **	61.72**	-1.17	-2.87	3.05
28	Kranti x RS 1	24.23	16.28	17.19	11.9	11.9	14.63*
29	Kranti x GM 1	27.88 *	18.89	21.56	8.88	8.24	12.208
30	Kranti x GM 2	43.29 **	36.88 *	32.09*	14.43	10.48	13.178

31	P.Vijay x RH 749	26.37	17.83	17.50	5.62	0	14.638
32	P.Vijay x Navgold	42.62 **	33.08 *	32.50*	5.26	3.45	9.76*
33	P.Vijay x RS 1	21.14	12.4	13.28	1.19	1.19	3.66
34	P. Vijay x GM 1	56.00 **	43.80 **	47.03**	-2.96	-3.53	0.00
35	P.Vijay x GM 2	25.86	19.17	15.00	10.23	6.43	9.02*
36	RH 749 x Navgold	41.04 **	40.93 **	40.53**	-2.76	-6.38	7.32
37	RH 749 x RS 1	18.61	17.98	18.91	-1.12	-6.38	7.32
38	RH 749 x GM 1	11.56	10.18	12.66	-3.91	-8.51	4.88
39	RH 749 x GM 2	24.91	22.89	22.55	3.37	-5.32	8.54
40	Navgold x RS 1	11.95	11.27	12.14	114.04 **	110.34 **	41.87**
41	Navgold x GM 1	19.7	18.12	20.78	-2.33	-3.45	2.44
42	Navgold x GM 2	28.47 *	26.49	25.94	-0.73	-5.75	0.00
43	RS 1 x GM 1	5.28	4.52	6.88	-4.14	-4.71	-1.22
44	RS 1 x GM 2	15.95	13.49	14.38	1.11	-2.38	0.00
45	GM 1 x GM 2	30.35 *	26.68	29.53	5.39	1.18	4.88
	Max	99.17	94.50	72.97	114.04 **	110.34 **	41.87**
	Min	5.28	3.88	-2.20	4.97	-8.51	-1.22

Table 2: Continued…

Sr. No.	Name of Cross	Seeds per siliqua			Seed yield per plant (g)		
		MP	BP	SH	MP	BP	SH
1	RH 119 x Urvashi	-2.39	-5.92	2.14	95.10 **	73.04 **	107.29**
2	RH 119 x RH 1134	14.29 **	10.53 **	20.00**	74.75 **	58.72 **	80.21**
3	RH 119 x Kranti	1.97	1.97	10.71**	10.6	-6.25	25.00
4	RH 119 x P.Vijay	9.97 **	5.26	14.29**	54.59 **	35.59 *	66.67**
5	RH 119 x RH 749	8.36 **	6.58	15.71**	19.81	5.08	29.17
6	RH 119 x Navgold	1.37	-2.63	5.71	35.79 *	27.72	34.38*
7	RH 119 x RS 1	-1.05	-7.24 *	0.71	62.50 **	60.67 **	48.96**
8	RH 119 x GM 1	0.69	-3.95	4.29	-5.26	-35.97 **	68.75**
9	RH 119 x GM 2	1.75	-4.61	3.57	148.35 **	143.01 **	135.42**
10	Urvashi x RH 1134	6.01	5.63	7.14*	72.32 **	67.83 **	101.04**
11	Urvashi x Kranti	-5.8	-9.21 **	-1.43	25.93	19.53	59.38**
12	Urvashi x P.Vijay	4.64	3.9	4.64	63.95 **	61.86 **	98.96**
13	Urvashi x RH 749	-2.08	-4.08	0.71	47.64 **	45.76 **	79.17**
14	Urvashi x Navgold	-1.07	-1.42	-0.71	55.56 **	46.09 **	75.00**
15	Urvashi x RS 1	0.73	-2.13	-1.43	42.57 **	25.22	50.00**
16	Urvashi x GM 1	-4.66	-5.67	-5.00*	6.52	-22.53 **	104.17**
17	Urvashi x GM 2	2.19	-0.71	0.00	89.42 **	71.30 **	105.21**
18	RH 1134 x Kranti	6.12 *	2.63	11.43**	0.42	-7.03	23.96
19	RH 1134 x P.Vijay	9.82 **	8.66 *	10.21**	50.66 **	44.92 **	78.13**
20	RH 1134 x RH 749	-1.04	-2.72	2.14	35.68 *	30.51	60.42**
21	RH 1134 x Navgold	0.35	-0.35	1.07	64.76 **	58.72 **	80.21**
22	RH 1134 x RS 1	7.64 *	4.23	5.71	81.63 **	63.30 **	85.42**
23	RH 1134 x GM 1	-2.86	-4.23	-2.86	-10.5	-35.97 **	68.75**
24	RH 1134 x GM 2	8.00 *	4.58	6.07	167.33 **	147.71 **	181.25**
25	Kranti x P.Vijay	-0.34	-4.61	3.57	42.28 **	36.72 *	82.29**
26	Kranti x RH 749	5.69	3.95	12.86**	17.07	12.5	50.00*
27	Kranti x Navgold	6.16 *	1.97	10.71**	37.99 **	23.44	64.58**
28	Kranti x RS 1	6.67 *	0	8.57*	51.63 **	27.34	67.71**
29	Kranti x GM 1	7.24 *	2.3	11.07**	-20.73 *	-40.32 **	57.29**
30	Kranti x GM 2	7.72 *	0.99	9.64**	52.94 **	32.03 *	76.04**

31	P.Vijay x RH 749	6.64 *	3.74	8.93**	53.39 **	53.39 **	88.54**
32	P.Vijay x Navgold	5.02	4.64	4.64	20.55	11.86	37.50
33	P.Vijay x RS 1	7.17 *	4.86	4.11	59.02 **	38.14 *	69.79**
34	P.Vijay x GM 1	0.72	0.36	-0.36	-34.23 **	-51.78 **	27.08
35	P.Vijay x GM 2	11.03 **	8.63 *	7.86*	64.93 **	47.46 **	81.25**
36	RH 749 x Navgold	3.14	0.68	5.71	68.95 **	56.78 **	92.71**
37	RH 749 x RS 1	3.57	-1.36	3.57	46.34 **	27.12	56.25**
38	RH 749 x GM 1	1.05	-2.04	2.86	-15.36	-37.94 **	63.54**
39	RH 749 x GM 2	4.64	-0.34	4.64	48.82 **	33.05 *	63.54**
40	Navgold x RS 1	10.62 **	7.86 *	7.86*	11.7	3.96	9.37
41	Navgold x GM 1	-1.08	-1.79	-1.79	-8.47	-35.97 **	68.75**
42	Navgold x GM 2	4.03	1.43	1.43	89.69 **	82.18 **	91.67**
43	RS 1 x GM 1	-1.85	-3.62	-5.00*	-14.12	-42.29 **	52.08**
44	RS 1 x GM 2	2.63	2.63	-2.50	130.00 **	122.58 **	115.63**
45	GM 1 x GM 2	2.95	1.09	-0.36	-6.94	-36.36 **	67.71**
	Max	14.29 **	10.53 **	20.00	167.33	147.71	181.25
	Min	-5.80	-9.21	-5.00	-34.23	-51.78	9.37

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Services provided by the vegetable producers' organisations to their members

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ABSTRACT

In the competitive and unstable environment it is necessary to facilitate small and marginal farmers by providing access to the markets, technical know- how, critical inputs, consultancy etc. One of the important objectives of Farmer producers' organization was to provide wide range of services to the member farmers and make them active partners of business activities. An attempt was made to study the services provided by the organization to their members. Three tahsils from Pune district and total eleven FPOs engaged in production and marketing of vegetables were purposively selected for the study. From selected VPOs, ten per cent respondents were randomly selected constituting sample of 200 members. The list of services was prepared and respondents were asked to tick mark against the availed items. Total number of tick marked items was the service score of an individual. The respondents were classified in three categories based on mean and standard deviation. Also service wise total number and frequency of respondents was worked out. The results of study revealed that majority (80.00 per cent) of the respondents received low to medium extent of services through the organization viz., participating in krishimela was, exposure visits, field trips 984.00 per cent), received timely payment after sale of produce (82.00 per cent), latest agricultural information (76.00 per cent), technical guidance (75.00 per cent), better profit margin (72.00 per cent). Only 18.00 per cent and 10.00 per cent members received credit and financial support through organization. There is a need to develop linkage with other stakeholders to provide wide range of services to the members.

Key words: Stakeholders, linkage

The future of sustainable agriculture growth and food security in India depends on the performance of small and marginal farmers. Limited investment capacity of these small farms is also an area of great concern. Limited access to critical inputs such as quality seeds, fertilizers, irrigation water, power and credit has created a hugely disabling ecosystem for the small farms. Taking into consideration these facts, Farmer producers' organizations were started with one of the important objectives to provide wide range of services *viz.,* supply of seeds, fertilizers, plant protection chemicals, farm machinery, technical guidance, consultancy, policy advocacy, insurance, credit *etc.* Need of agricultural information, technical guidance is the basic necessity of the farmers, as it plays a pivotal role in enlightening them, raising their level of knowledge. An attempt was made to study the various services provided by the farmer producers' organisations to their members.

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MATERIALS AND METHODS

In present study, multistage sampling procedure was followed for selection of study area. Pune district from western Maharashtra was purposively selected based on maximum number of FPOs in first stage. Considering area

FPO: Farmer Producers Organization; VPO: Vegetable Producers Organization

under vegetable and number of FPOs working in vegetable production and marketing, three talukas *viz*., *Khed, Junner and Purander* of Pune district were selected in second stage. Based on maximum number of members and organizations which are engaged in vegetable production were selected in third stage and renamed as Vegetable Producers' Organisations (VPOs) under study. Thus total eleven VPOs were purposively selected and 10 per cent of sample was drawn from each selected VPO by proportionate sampling method comprising total 200 respondents.

The list of various services expected to be provided to the member was prepared and respondents were asked to tick mark the items which they availed. Total number of tick marked items was the service score of an individual. On the basis of service score, mean and standard deviation were worked out and respondents were classified in three categories *viz.,* low, medium and high based on mean ± standard deviation. Also service wise total number and frequency of respondents was worked out.

RESULTS AND DISCUSSION

Data presented in Table 1 regarding services provided by the organization to their members stated that overwhelming majority (84.00 %) of the respondents had facilitated for participating in krishimelawas, exposure visits, field trips organized by agriculture department. Similar findings were observed by Patil (2014).

Also majority (82.00 %) of the members received timely payment after sale of produce through organization. Three fourth of the members stated that they were getting latest agricultural information (76.00 %), guidance on crop planning, plant protection, grading, packaging (75.00 %) and received better profit margin through collective sale (72.00 %).

Two third opined that they had received timely and good quality inputs (66.00 %), acquired skills on processing, seed production (67.00 %), consultancy services *viz.,* weather forecasting, pest disease outbreak (66.00 %), storage, grading, packaging services (64.00 %) through organization. Similar findings were reported by Chandrashekhara *et al.*, (2007), Prabhakar *et al.,* (2010[b]) and Patil (2014).

Table 1 Distribution of the members as per the services provided by the Vegetable Producers' Organisations (n=200)

Sr. No.	Type and quality of services	Frequency	Percent
A	Input supply		
i	Timely supply of agricultural inputs	136	68.00
ii	Provide good quality inputs at reasonable price	132	66.00
iii	Regular input supply as per farmers demand	110	55.00
B	Marketing of produce		
i	Provides grading, transportation and storage facilities to the members	128	64.00
ii	Provides better profit margin through collective sale	142	72.00
iii	Timely payment to the members after sale of produce	164	82.00
C	Credit supply		
i	Facilitate for preparing loan proposals	108	54 .00
ii	Provide timely subsidies	52	26.00
iii	Facilitate the members to get credit in time	40	20.00
D	Consultancy services		
i	Provides latest agricultural and technical knowledge to the members	158	76.00

ii	Provides information about weather forecasting, pest outbreak, market prices etc.	132	66.00
iii	Provides guidance on crop planning, plant protection, grading, packaging, standardization and marketing of produce etc.	150	75.00
E	HRD services		
i	Imparts need based training to the members	96	48.00
ii	Imparts skills on processing of produce, quality seed production	134	67.00
iii	Facilitates the participation of members in krishimelawas, exposure visits ,field trips etc.	168	84.00
F	Other welfare services		
i	Financial support to the members for domestic reason (marriage, higher education etc.)	36	18.00

More than half reported that producer organisation was facilitating the members for taking loan (55.00 per cent) and providing inputs on regular basis (54.00 per cent) to the members.

Similar findings were reported by Prabhakar *et al.*, (2010[b]) and Patil (2014).

On the contrary only 18.00 per cent and 10.00 per cent members received credit through organization and financial support for domestic reason respectively. This could be due to that farmers organizations might not having enough share capital to provide loan to the members, also might not taking financial risk as they are in developing stage.

Table 2 Distribution of the members according to their extent of services provided by the Vegetable Producers' Organisations

(n=200)

Sr. No.	Extent of services provided	Frequency	Percent
1	Low (Below 7 score)	48	24.00
2	Medium (7 to 12 score)	112	56.00
3	High (Above 12 score)	40	20.00
	Total	200	100.00

$\overline{X}$=9.41 S.D. = 2.19

The data from Table 2 revealed that 56.00 per cent of the respondents received the medium extent of services, followed by one-fourth (24.00 %) and two fifth (20.00 %) of the respondents who received low and high extent of services by the farmers organization, respectively. It can be concluded that majority (80.00 %) of the respondents received low to medium extent of services through their organization.

CONCLUSION

Study further can be concluded that organizations were providing services to the members in limited areas. There is lot of scope to diversify the activities and facilitate the members by linking with other stakeholders. Producers' organizations can expand the business so as to provide credit, subsidies and financial assistance to the members through developing linkage with banks, insurance company.

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Perception of farmers about soil health

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ABSTRACT

This study was conducted in Mahesana District of Gujarat State. Out of nine talukas of the district, three talukas *viz*., Unjha, Kadi and Bhecharaji were selected purposively on the basis of soil fertility indices (pH and EC) for the study. Five villages were randomly selected from each selected taluka. The purpose of the study was to know the perception of farmers about soil health. The study revealed that maximum number of farmers were middle to old aged, literate, had medium farming experience, small to medium land holding, small herd size, annual income up to 2 lakh, tube well as their major source of irrigation, ground water level between 400-600 feet and had cropping intensity ranging between 101-200 per cent. The indicators for good soil health perceived by a great majority of the farmers were: good and fast crop growth, more crop yield, dark brown soil colour and good soil tilth. While, water is not absorbed in the soil, salt come up to soil surface and frequent irrigation is needed were bad soil health indicators perceived by a great majority of the farmers. The purposes perceived important by the farmers for maintaining good soil health were; sustaining crop productivity, increasing soil water holding capacity, reducing irrigation cost and sustaining crop against water shortage. Among nine characteristics under study, farming experience, land holding and annual income had positive and significant correlation while, cropping intensity had negative and significant correlation with the perception of farmers about soil health.

Key words: Perception, Indicators, Soil Health

Perception is the thorough understanding of the concept through all the senses that makes the final impression of the concept in the mind of individual. Imbalanced use of fertilizers, low addition of organic matter and non-replenishment of depleted micro and secondary nutrients over the years, resulted in nutrient deficiencies and decrease in soil fertility. Soil health needs to be assessed at regular intervals to ensure that farmers apply the required nutrients while taking advantage of the nutrients already present in the soil (Kinyangi 2007). A fully functioning soil produces the maximum amount of agriculture produces at the least cost. Improving soil health is essential to maximize profitability. Managing for soil health (improved soil function) is mostly a matter of maintaining suitable habitat for the myriad of creatures that comprise the soil food web. Soil works for you if you work for the soil by using management practices that improve soil health and increase productivity and profitability immediately and into the future. Hence, it was thought to study the perception of the farmers about soil health in light of the following objectives.

i. To study the characteristics of the farmers
ii. To know the perception of farmers about soil health
iii. To ascertain relationship between selected characteristics of the farmers and their perception about soil health

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MATERIALS AND METHODS

The study was carried out in Mahesana District where, tube well is the main source of irrigation. Out of nine talukas of the district, three talukas *viz*., Unjha, Kadi and Bhecharaji were selected purposively on the basis of soil fertility indices (pH and EC) for the study. Five villages from each selected taluka and ten farmers from each selected village were randomly selected, making a sample of 150 farmers. The perception of indicators was measured with two point continuum *i.e.* agree and disagree with 2 and 1 score respectively. Mean score was calculated for assigning ranks. Structured interview schedule was used for collection of data. The farmers were interviewed personally and their responses were recorded. The data were tabulated and interpreted on the basis of frequency, mean, standard deviation and correlation coefficient.

RESULTS AND DISCUSSION

Characteristics of the farmers

The data regarding selected characteristics of farmers are presented in Table 1.

Table 1: Distribution of the respondents according to their characteristics (n= 150)

Sr. No.	Characteristics	Frequency	Percentage
01	Age		
	Young (Up to 35 years)	36	24.00
	Middle (36 to 50 years)	49	32.67
	Old (Above 50 years)	65	43.33
02	Level of education		
	Illiterate	03	02.00
	Primary (up to VII)	37	24.67
	Secondary (VIII to X)	72	48.00
	Higher Secondary (XI to XII)	24	16.00
	College	14	09.33
03	Farming experience (Years)		
	Low (up to 13)	24	16.00
	Medium (14 to 33)	104	69.33
	High (above 33)	22	14.67
	Mean: 23.47	SD: 10.02	
04	Land holding		
	Marginal (Below 1.00 ha)	23	15.33
	Small (1.01 to 2.00 ha)	48	32.00
	Medium 2.01 to 4.00 ha)	55	36.67
	Big (Above 4.00 ha)	24	16.00
05	Herd size		
	Small (up to 3 animals)	122	81.33
	Medium (4 to 6 animals)	21	14.00
	Large (above 6 animals)	07	04.67
06	Annual income (Rs.)		
	Up to 1,00,000/-	28	18.67
	1,00,001 to 2,00,000/-	62	41.33
	2,00,001 to 3,00,000/-	36	24.00
	3,00,001 to 4,00,000/-	13	08.67
	Above 4,00,001/-	11	07.33

07	Irrigation source		
	Tube well	115	76.67
	Open well	26	17.33
	Canal	08	05.33
	Tank	01	00.67
08	Water level (ft)		
	Up to 400	17	11.33
	400 to 600	96	64.00
	Above 600	37	24.67
09	Cropping intensity (%)		
	Up to 100	06	04.00
	101 to 200	119	79.33
	201 to 300	25	16.67

The data presented in Table 1 indicates that majority of the farmers were middle to old aged (76.00 per cent) and had medium experience of farming (69.33 percent). Almost all (98.00 per cent) were literate *i.e*. educated from primary to college level.

Further, majority of them had small to medium size of land holding (68.67 per cent), possessed small size of herd (81.33 per cent), had annual income up to Rs. 2 lakh (60.00 percent), tube well as their major source of irrigation (78.67 per cent), tube well water table from 400 to 600 feet (64.00 per cent) and had 101 to 200 per cent cropping intensity (79.33 per cent).

Perception of farmers about soil health

The responses of farmers regarding their perception about soil health were obtained against two aspects i) indicators of good soil health and ii) indicators of bad soil health.

Indicators of good soil health

The information regarding good soil health indicators as perceived by the farmers is presented in Table 2.

Table 2 Perception of farmers about good soil health indicators (n=150)

Sr. No.	Indicators	Farmers (%)		Mean Score	Rank
		Agree	Disagree		
1	Good and fast crop growth	93.33	6.67	1.93	I
2	More crop yield	89.33	10.67	1.89	II
3	Dark brown soil colour	85.33	14.67	1.85	III
4	Good soil tilth	81.33	18.67	1.81	IV
5	Good growth of root system	74.67	25.33	1.75	V
6	More earthworms	66.67	33.33	1.66	VI
7	Higher organic matter	63.33	36.67	1.63	VII

Table 2 reveals that 93.33 per cent of the respondents perceived that if the crop growth is good and fast it indicates good soil health. Whereas, 89.33 per cent of the farmers agreed to if soil gives more crop yield then the health of the soil is good. Further, 85.33 per cent of the farmers felt that if the soil colour is dark brown then the health of the soil is good. The 81.33 per cent farmers perceived that if soil has good soil tilth means it has good health. Majority of the respondents perceived that more earthworms (66.67 per cent) and higher organic matter (63.33 per cent) present in the soil, indicates good soil health.

From the foregoing discussion, it can be concluded that "good and fast crop growth",

"more crop yield", "dark brown color of soil" and "good soil tilth" were the indicators considered more important by the farmers for perceiving the good soil health, and were ranked first, second, third and fourth, respectively.

Indicators of bad soil health

The information regarding indicators of bad soil health as perceived by the farmers was also collected and presented in Table 3.

Table 3 Perception of farmers about indicators of bad soil health (n=150)

Sr. No	Indicators	Farmers (%)		Mean Score	Rank
		Agree	Disagree		
1	Water is not absorbed in soil	90.67	09.33	1.90	I
2	Salt comes up to soil surface	82.67	17.33	1.82	II
3	Frequent irrigation needed	80.00	20.00	1.80	III
4	Soil gets cracked	74.67	25.33	1.74	IV
5	Soil gets hard when dry	73.33	26.67	1.73	V
6	Plant growth remain slow	66.67	33.33	1.66	VI
7	*Vapsa* gets delay	63.33	36.67	1.63	VII
8	Poor seed germination	60.00	40.00	1.60	VIII
9	Crop show water shortage even after irrigation	56.00	44.00	1.56	IX

The data presented in Table 3 reveals that 90.67 per cent of the respondents felt that if the water is not absorbed in the soil shows that the soil health is bad. The 82.67 per cent and 80.00 per cent of the respondents perceived that if the salt comes up to soil surface and the soil needs frequent irrigation then the health of the soil is bad. Almost three-fourths (74.67 per cent) of the respondents perceived the bad soil health on the basis of cracking of soil. Moreover, 73.33 per cent of the respondents perceived the hardness of the soil as an indicator of bad soil health. The respondents also perceived that when the "plant growth remains slow" (66.67 per cent), "*vapsa* gets delayed" (63.33 per cent), "seed germination is poor" (60.00 per cent) and "crop shows water shortage even after irrigation" (56.00 per cent) then the health of the soil is not good.

It can be concluded that the most important indicators perceived by the farmers for bad health of soil were; "water is not absorbed in soil", "salt comes up to soil surface", "frequent irrigation needed", “soil gets cracked” and soil gets hard when dry” and were ranked first, second, third, fourth and fifth, respectively.

Purpose of maintaining soil health

The responses of the farmers regarding purpose of maintaining soil health were obtained and depicted in Table 4

Table 4 Perception of farmers regarding purpose of maintaining soil health (n=150)

Sr. No	Purposes	Farmers (%)		Mean Score	Rank
		Agree	Disagree		
1	Sustaining crop productivity	90.67	09.33	1.90	I
2	Increasing soil water holding capacity	84.00	16.00	1.84	II
3	Reducing irrigation cost and sustaining crop against water shortage	73.33	26.67	1.73	III
4	Increasing microbial activities	46.67	53.33	1.46	IV
5	Controlling soil erosion by conserving soil	33.33	66.67	1.33	V
6	Sustaining nutrients level in soil	30.00	70.00	1.30	VI

Data presented in Table 4 indicates that the perceived purposes of maintaining soil health by vast majority of the respondents were; to sustain crop productivity (90.67 per cent), increasing soil water holding capacity (84.00 per cent) and reducing irrigation cost and sustaining crop against water shortage (73.33 per cent) and ranked first, second and third, respectively.

Less than half of the respondents perceived that the soil health should be maintained to increase microbial activities in the soil (46.67 per cent), controlling soil erosion by conserving the soil (33.33 per cent) and to sustain the nutrients level in the soil (30.00 per cent) and were ranked fourth, fifth and sixth, respectively. This implies the poor perception of the farmers about these purposes of maintaining soil health.

Thus, from the discussion, it can be concluded that the purposes to maintain the good soil health perceived by the majority of the farmers were: "sustaining crop productivity", "increasing soil water holding capacity", "reducing irrigation cost and sustaining crop against water shortage" and "maintaining nutrients level in the soil".

Correlates of perception of the farmers regarding soil health

The correlation coefficient was worked out to find out the association between the characteristics of the farmers and their perception about soil health. The data are in this regards are presented in Table 5.

Table 5 Correlation between selected characteristics of farmers and perception about soil health

Sr. No.	Variables	Correlation Coefficient (r value)
1	Age	0.1464^{NS}
2	Education	0.1270^{NS}
3	Farming experience	0.1646*
4	Land holding	0.3660**
5	Herd size	0.0010^{NS}
6	Annual income	0.1646*
7	Irrigation source	0.0568^{NS}
8	Water level	0.0386^{NS}
9	Cropping intensity	-0.2334**

* = Significant at 0.05 level ** = Significant at 0.01 level NS = Not significant

A perusal of the data in Table 5 shows that farming experience had positive and significant association with perception of the farmers about soil health it indicates that farmers having more experience had positive perception. Land holding had positive and highly significant association with perception of soil health. It signifies that medium and large farmers had positive perception regarding soil health. Annual income had positive and significant association with farmers' perception. Cropping intensity had negative and significant association with perception of farmers about soil health. Rest of the characteristics of farmers *viz.*, age, education, herd size, irrigation source and water level had no association with perception of farmers about soil health.

CONCLUSION

Maximum number of farmers were middle to old aged, literate, had medium farming experience, small to medium land holding, small herd size, annual income up to 2 lakh, tube well as major source of irrigation, ground water level between 400-600 feet and had cropping intensity ranging from 101 to 200 per cent.

The indicators for good soil health perceived by a great majority of the farmers were: good and fast crop growth, more crop yield, dark brown soil

colour and good soil tilth while, water is not absorbed in the soil, salt come up to soil surface, frequent irrigation is needed, soil gets cracked and soil gets hard when dry were the indicators of bad soil health perceived by a great majority of the farmers.

The purposes perceived important by the majority farmers for maintaining good soil health were; sustaining crop productivity, increasing soil water holding capacity and reducing irrigation cost and sustaining crop against water shortage. Among nine characteristics under study, farming experience, land holding and annual income had positive and significant correlation while, cropping intensity had negative and significant correlation with perception of farmers about soil health.

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Variability study in sorghum (Bhal and Costal zone crop) field experiments and yardstick there of

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ABSTRACT

The data on C.V. % for sorghum crop yield along with other details of 87 field experiments conducted during 1989-90 to 2014-15 at Dhandhuka center (Bhal and Coastal zone crop), were collected and analyzed. The frequency distribution tables were prepared for various experimental factors. The upper fiducial limits (the yardstick) of C.V. % at 95% confidence based on non central 't' distribution were worked out for accepting the results of sorghum crop experiments which emerged as 17 %.

Key words: CV%, Fiducial limit, Plot size, Non central t distribution, Experimental variability

Statistics is used to interpret data and sometimes to determine whether data are suspect. Most researchers are familiar with the use of the least significant difference (LSD) needed to separate two or more means. Another statistical measurement familiar to many scientists and taught in most basic statistics course is the coefficient of variation (CV). This familiar measurement was created in the late 1800s as a measure of variability. However, ever since it was tacitly promoted as a measure of experimental validity by (Snedecor and Cochran, 1967). Its original purpose has been largely ignored. The experimental data provide information on controlled (treatment effect) and uncontrolled variation. The uncontrolled variation is expressed as experimental error, which could be quantified as an estimate called 'coefficient of variation (CV)'. Besides, fertility variation among experimental units (plots), the factors contributing toward uncontrolled variation are climatic and experimental. Therefore, CV of field experiments varies with the situation. Lower magnitude of CV is the reflection of reliability (precision) of the experimental results. The acceptable range of CV advocated by various workers is based on the experience with very limited number of experiments. There is a need to develop a yardstick (critical value) for CV based on theory and also on a large number of experiments conducted under different situations. The present paper deals with this aspect. Johnson and Welch, 1939 reported that for a normal distribution, the ratio of mean to standard deviation should be of the order of 3 or more. Further, they mentioned that 33% has often been stated as the permissible upper fiducial limit of CV. Tyagi *et al.*1973 and Patel *et al*., 1978 pointed out that CV obtained for the crops under study was found to be considerably higher than those reported from the uniformity trials. They stated that the yardstick for accepting experimental results should be worked out using CV observed in the experiments rather than in the uniformity trials. Bajpai and Nigam, 1980 suggested a working rule for deciding the value of $W2$ (weight corresponds to precision of the experiment) and developed an index to evaluate agricultural field experiments statistically. Gomez and Gomez, 1984 reported that CV varies greatly with the type of experiment, the crop grown and the character measured. They opined that the acceptable range of CV is 6 to 8

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% for varietal trials, 10 to 12 % for fertilizer trials and 13 to 15% for insecticidal and herbicidal trials on rice. Patel *et al*. 2001, reported that the when the coefficient of variation in pulse experiments in RCBD exceeds 23%, the experimental findings should not be considered for any purpose. Consequently, the CV has been used as a measure of validity for many types of agricultural experiments, from fertilizer experiments to crop performance trials. The CV was created as a measure of relative variability by Kendall and Stuart, 1977. Aflakpui, 1995 state that "there is no such thing as a CV for an experiment, only for individual variates." However, a CV of 10 to 15% for yield in experiments is generally expected by most field crop researchers. This expectation probably originated from Cochran and Cox's, 1957 statement that "the coefficient of variation is often between 5% and 15%." The basis for the CV is the assumption that the variance increases as the size of the mean increases. Allen *et al.*, 1978 reported a positive relationship for several crops, and Gotoh and Osanai, 1959 reported a positive relationship for wheat. Masood and Javed, 2003 reported based on the coefficients of variation the optimum plot sizes for maize trials were estimated to be (14.06 m^2) with square shape. Khan and Mead, 1998 presented uniformity data from field trials for improving precision of agriculture field experiments in Pakistan. Darji *et al*., 2010, developed the yardstick of CV % for forage crop experiment at 95 % confidence based on non central 't' distribution were worked out for accepting the results of forage crop experiments which emerged as 14%.

MATERIALS AND METHODS

The secondary yield character data of 87 sorghum field experiments conducted during 1989-90 to 2014-15. Information on plot size, number of treatments, replications, experimental design and disciplines was collected for each experiment.

The plot-wise yield data were subjected to statistical analysis and CV was estimated for individual experiments. The same was assumed as random variable in further analysis.

CV is a function of square root of mean square (S) and mean ($\bar{X}$).

$$CV = \frac{S}{\bar{X}} \quad (1)$$

The distributions of $\bar{X}$ and S have simple forms and Student's t distribution provides complete solution for testing the hypothesis or estimating fiducial limits relating to either m or s, singly. But t distribution cannot be used for $CV = \frac{S}{\bar{X}}$ Mckay, 1932 used non-central t-distribution for providing fiducial limits of CV.

Let z be a quantity distributed normally about zero mean with unit standard deviation and let w be a quantity distributed independently as χ^2, with degrees of freedom of χ^2

Then, if t is defined by the equation:

$$t = \frac{\delta + Z}{\sqrt{W}} \quad (2)$$

Where δ is some constant, then t is distributed in a manner depending only on d and f. This distribution is a non central t-distribution. When d equals zero, the distribution is the familiar Student's t.

Let an estimate of V be $v = S/\bar{X}$ the sample coefficient of variation.

Now, one may write

$$\frac{\sqrt{n}}{v} = \frac{\sqrt{n}\bar{X}}{S} = \frac{\sqrt{n}(\bar{X}\mu -)}{\sigma} + \frac{\sqrt{n}\mu}{\sigma} + \frac{S}{\sigma} \quad (3)$$

It appears from comparison with eq. (2) that $\frac{\sqrt{n}}{v}$ is distributed as non-central t with $f = (n - 1)$ and $\frac{\sigma\sqrt{n}}{v}$. This distribution can be used for test of significance and for providing fiducial limits of V (i.e. CV), as is done for μ. Since the objective was to work out the yardstick based on CV, the upper fiducial limit of CV using non-central t-distribution was estimated following the procedure given by (Johnson and Welch, 1939).

$$\text{(i) } CV = \frac{\sqrt{Error\ mean\ square}}{naem\ lareneG}$$

n = number of treatments × number of replications in a given experiment, $f = n - 1$ degrees of freedom.

Now, the upper fiducial limit of CV is,

$$CV_{LU} = \frac{\sqrt{n}}{\delta}(f, to\ \delta)$$

Where, $t_0 = \frac{\sqrt{n}}{CV}$

(ii) Find

$$Y = \left[1 + \frac{t_0^2}{2f}\right]^{1-/2}$$

Or

$$Y' = \frac{t_0}{\sqrt{2f}}\left[1 + \frac{t_0^2}{2f}\right]^{1-/2}$$

According to whether $\frac{t_0}{\sqrt{2f}}$ is greater than or less than 0.75. Consider $\frac{t_0}{\sqrt{2f}}$ lies between – 0.75 and 0.75, otherwise consider *Y*.

(iii) If *f* > 9, calculate $\frac{12}{\sqrt{f}}$

(iv) Select desired probability level of confidence, i.e. *e* and obtain $\lambda(f, t_0, \varepsilon)$ from the table in (Johnson and Welch, 1939) interpolating with respect to the quantities obtained in (ii) and (iii).

(v) Calculate

$$\delta(f, t_0, \varepsilon) = t_0 - \lambda\left[1 + \frac{t_0^2}{2f}\right]^{-1/2}$$

In the present investigation, the yardstick of CV for field experiments was worked out using two concepts: (i) average upper fiducial limit of CV for each of the 87 sorghum crop field experiments was worked out separately and then average of these upper fiducial limits was computed, and (ii) upper fiducial limit of CV based on average size of experiments, i. e. degree of freedom. The upper fiducial limit of 95 % and 90 % worked out using the theory of truncated t distribution as described by Johnson and Welch, 1939.

RESULTS AND DISCUSSION

Table 1 Upper fiducial limit of CV % for different disciplines of sorghum (Bhal and Coastal zone) crop

Discipline	No. of expt.	CV %	U L		Range		CV % > 16.18	
			(0.05)	(0.10)	(0.05)	(0.10)	No.of expt.	Proportion
Agronomy	30	14.10	16.95	16.25	2.84	2.15	7	8.00
Pl.Breeding	57	12.24	15.77	14.88	3.53	2.64	10	11.49
Average	87	12.88	16.18	15.35				

The results presented in Table 1 revealed that mean CV % and upper fiducial limits of average value of all the discipline except for Agronomy and soil science disciplines, were below the mean CV% (12.88).

Table 2 Upper fiducial limit of CV % for different design sorghum (Bhal and Coastal zone) crop

Design	No. of expt.	CV %	U L		Range		CV % > 16.18	
			(0.05)	(0.10)	(0.05)	(0.10)	No. of expt.	Proportion
FRBD	11	18.02	21.98	21.02	3.96	3.00	5	5.74
RBD	61	12.15	15.70	14.80	3.55	2.65	10	11.49
Split plot	15	12.07	13.85	13.44	1.78	1.37	7	8.00
Average	87	12.88	16.18	15.35				

The design used in Dhandhuka center (bhal and coastal zone) crop experiments (Table 2) indicated that the higher upper fiducial limits (>16.18%) were observed for FRBD design. RBD and split plot design were within average fiducial limit.

Table 3 Upper fiducial limit of CV % for different treatments of sorghum (Bhal and Coastal zone) crop

Treatments	No. of expt.	CV %	U L		Range		CV % > 16.18	
			(0.05)	(0.10)	(0.05)	(0.10)	No. of expt.	Proportion
< 6	3	11.25	15.55	14.40	4.30	3.15	0	00.00
6-10	46	10.62	13.89	13.05	3.27	2.43	4	4.59
11-15	28	16.21	19.66	18.82	3.45	2.61	9	10.34
16-20	9	14.76	17.56	16.89	2.80	2.13	4	4.59
21-25	1	11.70	13.33	12.95	1.63	1.25	0	00.00
Average	87	12.88	16.18	15.35				

The results presented in Table 3 revealed that experiments conducted with the set of treatments were within average fiducial limit of CV % except treatments 11-15 and 16-20.

Table 4 Upper fiducial limit of CV % for different plot size of sorghum (Bhal and Coastal zone) crop

Plot size (m^2)	No. of expt.	CV %	U L		Range		CV % > 16.18	
			(0.05)	(0.10)	(0.05)	(0.10)	No. of expt.	Proportion
<3	0	-	-	-	-	-	-	
3-6	1	18.54	22.03	21.21	3.49	2.67	1	1.14
6-9	20	17.20	20.94	20.03	3.74	2.82	8	9.19
9-12	58	11.32	14.56	13.74	3.24	2.42	6	6.89
12-15	7	13.45	16.21	15.55	2.76	2.10	2	2.29
15-18	1	7.20	8.30	8.06	1.10	0.86	0	0.00
Average	87	12.88	16.18	15.15				

The results presented in Table 4 revealed that mean CV % and upper fiducial limits were within limit of average value for all plot size except for 3-6, 6-9 and 12-15 sq.m. plot size. The upper fiducial limit, mean CV % and proportion of experiments for plot size 9-12 sq.m. was less than average fiducial limit. Under the circumstances plot size 9-12 sq.m. seems to be optimum plot size on Dhandhuka center (Bhal and coastal zone) for sorghum crop experiments. However, it needs confirmation by plot technique study for different location.

YARDSTICK OF C.V. % FOR SORGHUM CROP EXPERIMENTS

The C.V. % data of 87 field experiments were used to fit non central 't' distribution and to work out upper fudicial limit of C.V. at 0.05 level of probability. According the upper fiducial limit of C.V. % at 95 per cent confidence level of C.V. % was worked out to be 16.18 per cent. Thus, the results suggested that about 17 percent C.V. % should be considered as a yard stick for sorghum crop field experiments. These having C.V. % > 17 should be rejected for drawing scientific conclusion.

Table 5 The average upper fiducial limit and yardstick for CV % for the experiments of sorghum crop

Name of Crops	No. of experiments	Mean CV %	Upper fiducial limit of CV %		Overall yardstick of CV%
			0.95	0.90	
Sorghum	87	12.88	16.18	15.15	17 %

Table 6 Power of F-test as influence by CV%

Classes CV%	No.of experiments	F-test		
		Significant	Non-Significant	Ratio
1.0-11.0	41	38	3	0.08
11.0-21.0	37	30	7	0.23
21.0-31.0	6	6	0	0.00
31.0-41.0	3	0	3	0.00
>41	0	0	0	0.00
Total	87	74	13	0.18

The ratio of number of experiments having non-significant to significant F-test was worked for each class of frequency distribution (Table 6). The results revealed that the ratio increased with the increase in CV of the experiments. It also indicated that the efficiency (of detecting difference in treatment means) of F-test decreased with the increase in CV of experiments. The average ratio was observed to be 0.18. The ratio for the class 11.0-21.0 % was almost equal to the average ratio. The class included 16.18 %, the mean CV of all experiments. It can be seen from Table 6 that more than 50% of experiments having 17 % and more CV failed to detect difference in treatments means. Results clearly showed that when the coefficient of variation in Sorghum (Bhal and Coastal zone) crop experiments conducted in RBD exceeds 17 %, hence the experimental finding should not be considered for any purpose.

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Crop response to plant nutrients in predominant cropping system of Mehsana district of Gujarat

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ABSTRACT

A field experiment was conducted at 24 farmers field in Mehsana district of North Gujarat Agro climatic zone of Gujarat among them 12 farmers falls under high productive block of Visnagar Taluka (Laxmipura, Savala- Ravlapura and Ganeshpura villages) and 12 farmers falls under low productive block of Kadi Taluka (Nandasan, Borisana and Ambaliyara villages) under On Farm Research Programme, SDAU, Jagudan with seven fertility levels were tried (T_1: Control, T_2: Only recommended dose of Nitrogen, T_3: recommended dose of Nitrogen and Phosphorus, T_4: recommended dose of Nitrogen and Potash, T_5: Recommended dose of Nitrogen, Phosphorus and Potash, T_6: Recommended dose of Nitrogen, Phosphorus and Potassium along with micronutrients (15 kg $MgSO_4$ in cotton and 25 kg Zn $SO_{4.7}H_2O$ in wheat) and T_7: Farmers Practices (*i.e* 132 +46 +00 in cotton and 112 +48 + 0, N:P:K in wheat crop), were evaluated in randomized block design with the consideration of farmers as a replications. The treatment T_6: Recommended dose of Nitrogen, Phosphorus and Potassium along with micronutrients (15 kg $MgSO_4$ in cotton and 25 kg ZnSo4 Zn SO_4 in wheat) recorded the significantly highest wheat equivalent yield during individual year and in pooled results also. The highest system productivity was recorded under the treatmentT_6 which was followed by T_5. The maximum Nutrient use efficiency was recorded when only recommended dose of nitrogen and potassium was applied to both the crops of sequences (T_4) Significantly highest net and gross profit of a sequence per ha was registered under T_6 followed by T5. Similarly m system profitability was also recorded maximum under the treatment T_6.

Key words: Fertilizer dose, nutrient use efficiency, system productivity, system profitability, and wheat equivalent yield

Normally, insufficiency of one plant nutrient limits the efficiency with which other plant nutrients are taken up, reducing crop yield. Unbalanced availability of nutrients can lead to mining of soil reserves for nutrients in short supply and to losses of plant nutrients supplied in excess. Lack of balance also encourages excessive uptake of the nutrients supplied in excess, decreasing the productivity of those nutrients. Unbalanced fertilization is an uneconomic waste of scarce resources. Nitrogen is the most important fertilizer element playing vital role in yield improvement of wheat and cotton and the element is frequently reported as deficient in agricultural soils (Islam, 1990). Abedi *et al.,* (2010) investigated wheat response to different levels of nitrogen fertilizer and stated that the highest wheat grain yield was achieved when the plants were fertilized with 160 kg N ha^{-1}. Recommended optimum dose of nitrogen and further increase in application resulted in

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increase of seed cotton yield (Varshney, 1979). Phosphorus is second only to nitrogen in importance as an essential crop nutrient. More than 80 % of soil P is unavailable for plant use (Batten, 1992). It is critical for plant growth, especially in the early jointing stages and for enhancing grain yield and yield components (Römer and Schilling, 1986).

In North Gujarat, the cotton-wheat rotation is the dominant cropping system. The productivity of cotton and wheat in North Gujarat has increased due to adoption of high yielding semi-dwarf varieties and application of greater doses of chemical fertilizers. Fertilizer application levels in many areas are now at or above recommended levels. There are reports of declining factor productivity*, i.e.,* a need for increasing recommended dose of fertilizers rates to maintain current yield levels. Therefore to find out the on-farm crop response to plant nutrients in predominant cotton – wheat cropping systems of Mehsana district and to understand the factors that may be affecting productivity as related to the RDF use on farmer's fields, we analyzed the four years data of fertilizer application experiment.

MATERIALS AND METHODS

A field experiment was conducted at 24 farmer's field in Mehsana district. Among them 12 farmer's falls under high productive block of Visnagar Taluka (Laxmipura, Savala- Ravlapura and Ganeshpura villages) and 12 farmers falls under low productive block of Kadi Taluka (Nandasan, Borisana and Ambaliyara villages) during kharif and rabi season of 2013-14 to 2016-17 under On Farm Research Programme, SDAU, Jagudan. The site has a semi-arid sub-tropical climate with severe hot summers and fairly cool winters. The annual average rainfall is 580 mm. The soil of the experimental site is sandy loam in texture. Seven fertility levels were tried (T_1: Control, T_2: Only recommended dose of Nitrogen, T_3: recommended dose of Nitrogen and Phosphorus, T_4: recommended dose of Nitrogen and Potassium, T_5: Recommended dose of Nitrogen, Phosphorus and Potassium, T_6: Recommended dose of Nitrogen, Phosphorus and Potassium along with micronutrients (15 kg $MgSO_4$ in cotton and 25 kg $ZnSO_4$ in wheat) and T_7: Farmers Practices (*i.e* 132 +46 +00 in cotton and 112 +48 + 0, N:P:K in wheat crop), were evaluated in randomized block design with the consideration of farmers as a replications (location). Urea, Di-ammonium phosphate and muriate of potash were use as source of fertilizers and fertilizers was applied based on RDF of both crops. (180 kg N/ha and 120-60-00 NPK kg/ha, respectively). Each year, cotton was sown in may- June with the 90 cm row spacing. After harvest of cotton, wheat was sown in November using 120 kg/ha seed rate with rows spacing of 22.5 cm. The varieties used for sowing was Bollgaurd – II and GW 496 of respective crop. The gross and net plot size were 135sq.mt and 105.3 sq.mt., respectively.

The system productivity of the cropping systems was computed by converting the yield of two crops into the wheat equivalent yield, based on the prevailing market price and dividing by the number of days per year that crops occupied the land in a particular system. As per treatments basal and top dressing of fertilizers were applied to both the crops. All the recommended practices were adopted as per nee of crops.

RESULTS AND DISCUSSION

System productivity

It is evident from the data presented in the table 1 and 2 that there was significant variation in equivalent yield among the cropping system due different treatments of applied fertilizers dose during all four years of the experiment and in

pooled results. The significantly highest wheat equivalent yield was recorded under the treatment T_6 during individual years as well as in pooled results (12900, 8022, 8986, 6979 and 9436 kg/ha, respectively). While significantly lowest wheat equivalent yield was recorded with the treatment T_1 in which no fertilizers was applied. In case of system productivity (kg/ha/day), it was highest (25.9 kg/ha/day) under the cotton- wheat cropping systems in which recommended dose of fertilizer along with micronutrients was applied (T_6) as compared to the other treatments of cropping system followed by T_5 (24.2 kg/ha/day), while lowest system productivity was recorded with the absolute control (12.1 kg/ha/day). From the data presented in the tasble-3, it can be seen that the treatment T_6 which received full dose of recommended fertilizers and 15 kg $MgSO_4$ in cotton and 25 kg $ZnSO_4$ in wheat gave significantly higher individual cotton crops yield and wheat crop yield, which was at par with treatment T_5 in which only recommended dose of fertilizers was applied to both the crops of sequence. However, the maximum nutrient use efficiency (kg/kg fertilizer applied) was recorded with T_7 (22.77 kg/ha/day) in which only recommended dose of nitrogen and potassium was applied to both the crops of sequences followed by treatment T_2 (22.14 kg/kg fertilizer applied), while lowest (18.50 kg/kg fertilizer applied) with full dose of recommended dose of fertilizers along with micronutrients (T_6) applied to the both the crops.

System profitability

Significantly the highest gross and net profit of a sequence were registered under T_6 (Rs 165132 per ha and Rs 83056 per ha) followed by T_5 (Rs 154517/ha and Rs 73368/ ha). Maximum system profitability (Rs. 227.6 ha per day) and BCR (2.01) were recorded in the treatment T_6 in which 100 % RDF along with micronutrient were applied followed by treatment T_5 (Rs. 201.0 ha per day and 1.90), whereas the lowest values of system profitability was found under absolute control (Rs. 21.1 ha per day).

CONCLUSION

It was concluded that for getting higher productivity and profitability of predominant cotton- wheat crop sequence farmers of both high and low productivity block of Mehsana district can applied recommended dose of fertilizers along with 15 kg $MgSO_4$ in cotton and 25 kg ZnSO4 in wheat crop.

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Table 1 Wheat equivalent yield, gross profit and net profit as influenced by different treatments of plant nutrients in predominant cropping system of Mehsana (Gujarat) (pooled of four years)

Treatment	2013-14			2014-15			2015-16			2016-17			Pooled		
	Wheat equivalent yield (kg/ha)	Gross profit of system (Rs/ha)	Net profit of system (Rs/ha)	Wheat equi. yield (kg/ha)	Gross profit of system (Rs/ha)	Net profit of system Rs/ha)	Wheat equivalent yield (kg/ha)	Gross profit of system (Rs/ha)	Net profit of system (Rs/ha)	Wheat equi. yield (kg/ha)	Gross profit of system (Rs/ha)	Net profit of system (Rs/ha)	Wheat equi. yield (kg/ha)	Gross profit of system (Rs/ha)	Net profit of system (Rs/ha)
T_1	5729	85936	8567	4055	70955	9313	4522	79127	10465	4197	73452	2391	4421	77368	7684
T_2	9115	136719	55240	5798	101471	35734	6350	111118	37515	6607	115625	39770	6642	116233	42065
T_3	10667	159998	73894	6619	115833	45721	7559	132278	53816	7586	132757	51662	7727	135216	56273
T_4	10751	161258	77937	6642	116238	48548	7414	129752	53655	7723	135152	57486	7749	135600	59406
T_5	12099	181490	93662	7552	132167	60102	8568	149948	69322	8826	154464	70386	8830	154517	73368
T_6	12900	193501	104334	8022	140391	67376	8986	157258	75904	9679	169376	84609	9436	165132	83056
T_7	10786	161791	77799	6707	117364	48213	7642	133734	56113	7192	125865	44973	7696	134689	56774
S. Em	262	3936	3926	91	1599	1599	117	2055	1941	129	2254	2327	93	1627	1612
CD	734	11007	10979	256	4473	4473	328	5745	5428	360	6302	6508	260	4549	4508
CV %	12.5	12.5	27.4	6.9	6.9	17.4	7.9	7.9	18.6	8.5	8.5	22.7	6.1	6.1	14.6

Table 2 System productivity, system profitability, nutrient use efficiency and economics as influenced by different treatments of plant nutrients in predominant cropping system of Mehsana (Gujarat) (pooled of four years)

Treatment	Pooled							
	Wheat equi. yield (kg/ha)	Gross profit of system (Rs/ha)	Net profit of system (Rs/ha)	Mean cost of cultivation (Rs/ha)	BCR	System productivity (kg/ha/day)	System profitability (Rs/ha/day)	Nutrient use efficiency (kg/kg)
T_1	4421	77368	7684	69684	1.11	12.1	21.1	-
T_2	6642	116233	42065	74169	1.57	18.2	115.2	22.14
T_3	7727	135216	56273	78943	1.71	21.2	154.2	19.32
T_4	7749	135600	59406	76194	1.78	21.2	162.8	20.94
T_5	8830	154517	73368	81149	`1.90	24.2	201.0	18.79
T_6	9436	165132	83056	82076	2.01	25.9	227.6	18.50
T_7	7696	134689	56774	77914	1.73	21.1	155.5	22.77
S. Em	93	1627	1612					
CD	260	4549	4508					
CV %	6.1	6.1	14.6					

Table 3 Seed cotton yield(kg/ha) and wheat yield(kg/ha) as influenced by different treatments of plant nutrients in predominant cropping system of Mehsana (Gujarat) (pooled of four years)

Treatment	2013-14		2014-15		2015-16		2016-17		Pooled	
	Cotton yield	Wheat grain yield	Cotton yield	Wheat grain yield	Cotton yield	Wheat grain yield	Cotton yield	Wheat grain yield a)	Cotton yield	Wheat grain yield
T_1	957	1976	972	1914	927	1873	790	1691	911	1863
T_2	1705	2725	1348	2647	1304	2647	1402	2257	1440	2569
T_3	2006	3175	1491	3103	1537	3108	1607	2585	1660	2993
T_4	2116	2986	1580	2934	1556	2948	1685	2516	1734	2846
T_5	2287	3566	1787	3377	1812	3366	1931	2865	1954	3294
T_6	*2403*	3873	1848	3632	1870	3567	2084	3243	2051	3579
T_7	2092	3155	1556	3054	1580	3076	1568	2342	1699	2906
S. Em	64	64	28	48	34	4	44	47	27	29
CD	180	180	77	136	95	130	124	132	75	82
CV %	16.3	10.3	8.9	8.1	11.0	7.7	13.7	9.7	8.1	5.0

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Impact of interventions/ diversification in farming system on profitability and sustainability of small farmers of Mehsana district of Gujarat

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ABSTRACT

A field experiment was conducted at 24 farmer's field in Mehsana district of North Gujarat Agro climatic zone of Gujarat. Among them, 12 farmers fall under high productive block of Visnagar Taluka (Laxmipura, Savala- Ravlapura and Ganeshpura villages) and 12 farmers fall under low productive block of Kadi Taluka (Nandasan, Borisana and Ambaliyara villages) under the On Farm Research Programme, SDAU, Jagudan through different interventions or diversification. Results revealed that, the intensification/ diversification/ interventions increased net income of small land holders in low productive block of Kadi (Mehsana) from Rs 23117 to Rs 66134 per ha with the increase in net income to the tune of 20.3 to 65.1 % over their existing farming system, while under high productive block (Visnagar taluka) the range of increasing net profit per ha was Rs 9550 to Rs 95247per ha with the percent increase from 11.2 to 68.1% in net income. The response of intensification/diversification/ interventions was relatively higher (44.8 %) under low productive block of Kadi Taluka over high productive block of Vishnagar Taluka of Mehsana district.

Key words: Diversification, existing system, farming system, intervention

Globally food security is one of the largest concerns, particularly considering increasing global food demand related to projected population growth. Crop production can be increased by expanding crop land area (extensification) and/or by increasing crop yield (intensification, production/crop land area). It is contended that viability of small farms could be improved only through intensification/ diversification of agriculture. Diversification is an on-farm strategy that is generally propagated as a measure against risk. The theory is that profit with specialization in a single crop will be greater, but two or more products may be produced to reduce the risk of very low incomes in some years (Binding *et al*., 1993). Studies also revealed that fruits and vegetables offer immense scope to increase income levels of small holders and improve the productivity of scarce resources (Joshi *et al*., 2003). In North Gujarat, the sole cotton-wheat rotation is the dominant cropping system, where the productivity of sole cotton and sole wheat in North Gujarat has been increased due to adoption of high yielding semi-dwarf varieties and application of greater doses of chemical fertilizers. There are reports of declining factor productivity; hence there is a need for intensification or diversification of existing farming system. Therefore, the data of three years of intensification/ diversification/ interventions in farming system is presented here as under.

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MATERIALS AND METHODS

Data analyzed in this study were obtained from a field experiment conducted at 24 farmer's field in Mehsana district of North Gujarat Agro climatic zone of Gujarat. Among them, 12 farmers fall under high productive block of Visnagar Taluka (Laxmipura, Savala- Ravlapura and Ganeshpura villages) and 12 farmers fa under low productive block of Kadi Taluka (Nandasan, Borisana and Ambaliyara villages) under farming system diversification scheme of On Farm Research Programme, SDAU, Jagudan. The site has a semi-arid sub-tropical climate with severe hot summers and fairly cool winters. The annual average rainfall is 580 mm. The soil of the experimental site is sandy loam texture. Each year under predominant cropping system, cotton was used to sow in may- June with the 90 cm spacing and castor was used to sow during middle of August with the spacing of 120 to 150 cm raw spacing. After harvest of cotton, wheat was used to sow in November using 120 kg/ha seed rate in rows spacing of 22.5 cm apart. The farmers of low and high productivity blocks of Mehsana district were following the only sole castor or sole cotton or sole mustard and/ or sole wheat cropping system before 2013-14, but after that under the On Farm Research Programme, SDAU, Jagudan existing cropping system were diversified, *i.e.,* wheat with Lucerne, castor with fennel, wheat with tobacco and wheat with *Rabi* fennel, intensification of existing cropping system through relay cropping of castor in cotton, lucerne in castor, relay cropping of cotton in green gram and intervention in livestock and cropping system were followed. For calculating profitability, return was calculated using the prevailing market price of different commodities in the different years of the experiment.

RESULT AND DISCUSSION

The low productive block of Kadi taluka were intensified through relay cropping of castor in cotton, lucerne in castor, green gram in cotton and diversified cropping system through wheat with fennel, lucerne with oat and cotton with vegetables. Data presented in the Table-2 and depicted in the Figure 1 and 2 revealed that all 12 farmers of Kadi block adopted either intensification or diversification during *Kharif* season or in *Rabi* season along with livestock in which interventions were adopted. Due to adoption of intensification/diversification/ intervention in livestock and cropping system, farmers were benefited by increasing net profit ranges from Rs 23117 to Rs 73126 per ha. The percentage increase in net profit ranging from 20.30 to 65.10 % over their existing farming system. The average increase in net profit of 12 farmers farming system was Rs 44923 per ha (44.8 %) over their existing farming system.

Similarly, the farmers of high productive block of Visnagar talukas also followed the intensification of lucerne and chicory in castor, lucerne in mustard, relay cropping of green gram in cotton and relay cropping of *Rabi* fennel in castor or diversification of wheat with tobacco and wheat with mustard or intervention in livestock and cropping system. They were also benefitted through intensification/ diversification/ interventions in livestock and cropping system. The range of increasing in net profit of farming system through intensification/diversification/ interventions was varied from Rs 9550 to Rs 95247 per ha and in term of percentage it was 11.2 to 8.1 % over their existing farming system. The average increase in net profit of 12 farmers farming system was Rs 37095 per ha (37.00 %) over their existing farming system. The response of intensification/diversification/ interventions was relatively higher (44.80 %) under low productive block Kadi of Mehsana district over high productive block Vishnagar (37.00 %).

From the results it can be concluded that the productivity and profitability of existing farming system can be increased by the adoption of intensification in cropping system or diversification of cropping system or adoption of interventions in cropping system and livestock

under low and high productive block of Mehsana district. The response of intensification/ diversification/ interventions was relatively higher under low productive block (Kadi) over high productive block (Visnagar) of Mehsana district.

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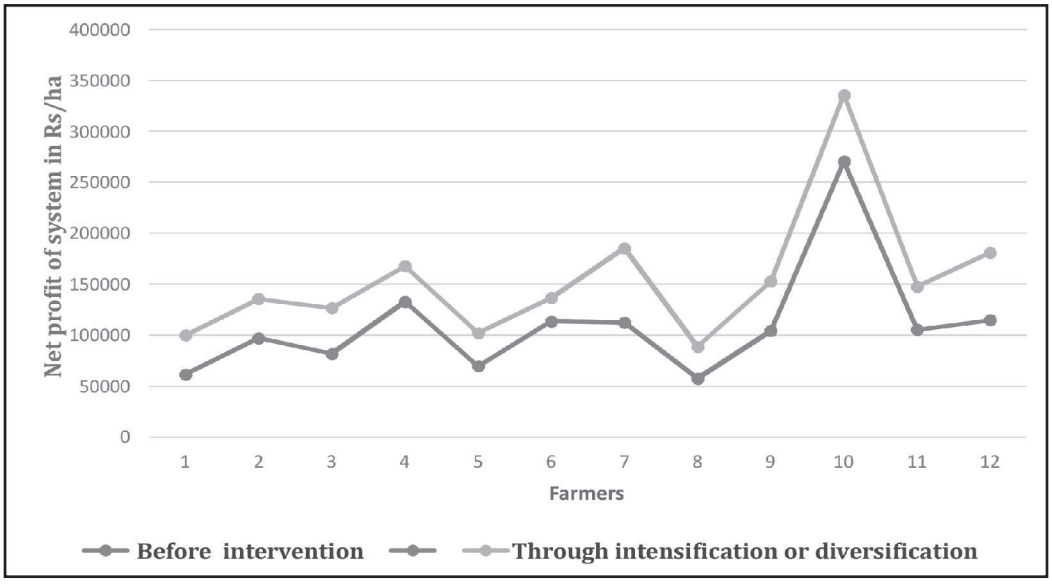

Figure 1 Effect of interventions /intensification/diversification on net profit of farming system under low fertility block(Kadi) of Mehsana

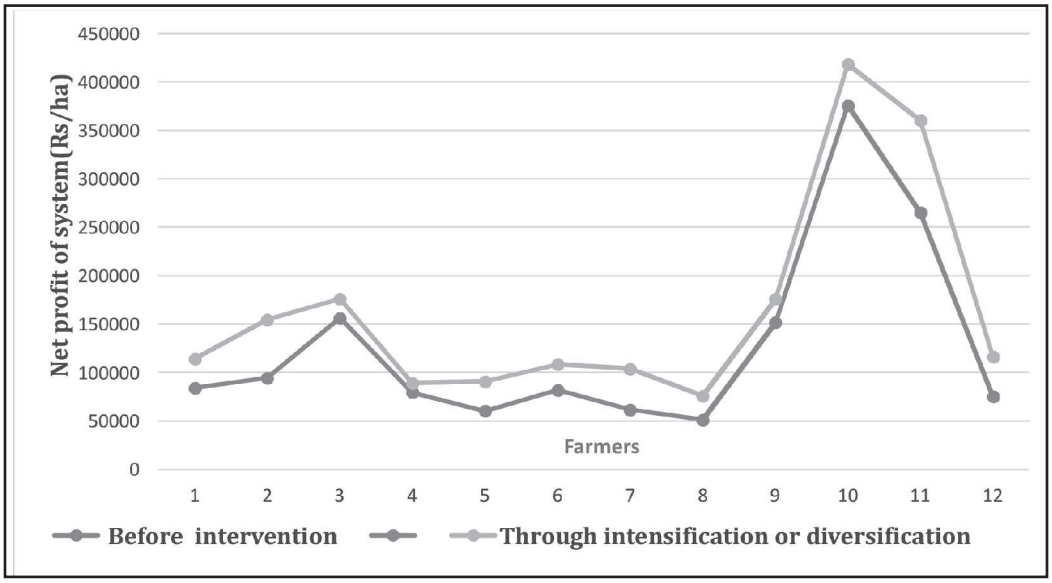

Figure 2 Effect of interventions//intensification/diversification on net profit of farming system under high fertility block (Visnagar) of Mehsana

Table 1 Existing farming system and types of intensification or diversification or interventions adopted in farming system by farmers

Block	Farmer	Existing cropping system	Intensification adopted	Type of Diversifiction
Kadi Low productivity	1	Sole cotton and sole castor	Castor in cotton, Lucerne in castor	Nil
	2	Sole castor	Lucerne in castor	Nil
	3	Sole cotton and sole castor	Greengram in cotton,Lucerne in castor, Greengram in castor	Nil
	4	Sole cotton and sole castor	Lucerne in castor, Greengram in cotton	Nil
	5	Sole cotton andsole wheat	Greengram in cotton, Wheat with lucerne	Wheat with fennel
	6	Sole cotton and sole castor	Castor in Greengram,Greengram in cotton	Wheat with fennel
	7	Sole cotton	Greengram in cotton	Wheat with lucerne
	8	Sole cotton, sole Wheat	Greengram in cotton, Wheat with lucerne	Nil
	9	Sole castor, sole Lucerne	Lucerne in castor, Lucerne in chikory	Nil
	10	Sole castor, sole Lucerne	Lucerne in castor, Lucerne in chikory	Cotton with Bhinda/Cowpea
	11	Sole wheat	Lucerne in wheat	Lucerne with oat
Vishnagar High productivity	12	Sole Mustard, Sole castor	Lucerne in Mustard,Lucerne in castor	Nil
	13	Sole cotton	Intensification of lucern and Chikory in castor	Nil
	14	Sole castor	Intensification of lucern in mustard and greengram in cotton	Nil
	15	Sole castor	Intensification of Green gram in castor	Nil
	16	Sole castor	Intensification of Green gram in cotton	Nil
	17	Sole castor	Intensification of castor in cotton	Nil
	18	Sole castor	Intensification of fennel in castor	Nil
	19	Sole castor	Intensification of fennel in castor	Nil
	20	Sole castor	Nil	Wheat with tobacco
	21	Sole castor	Nil	Wheat with mustard
	22	Sole castor	Intensification of lucern in castor	Nil
	23	Sole castor	Nil	Wheat with tobacco
	24	Sole cotton	Intensification of Green gram in cotton	Nil

Table 2 Net profit of system as influenced by intensification / diversifications/ interventions in farming systems over existing farming system

	Net profit of system before intervention/ existing			Net profit of system through intensification/ diversification/interventions			Increased due to diversification/intensification			
Farmers	Crops	Dairy	Total	Crops	Dairy	Total	Rs /ha	%	Average	
Low productive block of Kadi (Mehsana)										
1	161078	99547	61532	218340	118317	100023	38492	62.6	Rs /ha	%
2	230227	132933	97294	283396	147725	135672	38378	39.4		
3	200483	118605	81878	269373	142637	126737	44859	54.8		
4	310231	177309	132922	339206	171148	168058	35136	26.4		
5	217813	148128	69685	246775	144618	102157	32472	46.6		
6	217605	103947	113658	262306	125532	136775	23117	20.3		
7	307114	194735	112379	386590	201085	185505	73126	65.1	44923	44.8
8	171911	114278	57633	205291	116499	88792	31159	54.1		
9	293471	188934	104537	421103	267950	153153	48616	46.5		
10	741310	470693	270617	778759	442958	335801	65185	24.1		
11	354314	248847	105468	401372	253500	147872	42404	40.2		
12	270903	155972	114932	341526	160460	181066	66134	57.5		
High productive block of Visnagar(Mehsana)										
13	195901	111709	84192	216656	102479	114177	29985	35.6		
14	245315	150626	94689	288682	133843	154839	60150	63.5		
15	393579	237078	156502	417358	241189	176169	19667	12.6		
16	186822	107296	79526	174935	85860	89076	9550	12.0		
17	162335	102067	60268	198581	107823	90757	30489	50.6		
18	175880	93909	81971	221709	113201	108508	26538	32.4	37095	37.0
19	145305	83595	61710	203596	99851	103744	42035	68.1		
20	139955	88495	51460	177730	101870	75860	24400	47.4		
21	334128	182268	151860	324320	148592	175728	23868	15.7		
22	676038	300102	375936	698017	279812	418205	42268	11.2		
23	455855	190912	264943	548020	187830	360190	95247	35.9		
24	140968	65730	75238	196982	80797	116185	40947	54.4		

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Ascertain of volatile oil in selective seed spices from diverse sources

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ABSTRACT

Seed spices such as cumin, fennel and coriander are high value and low volume case crop for farmers of arid and semi-arid region of Gujarat and Rajasthan. Spices have diverse nature of uses from culinary to medicine ingredient that are salubrious nature to human, even to animals. The spice content play a significant role for their quality evaluation and obtain value addition products. Volatile oil also knows as essential oil a major vital content and value added product from spices. To find out volatile oil content in different sources of seed spice have useful to procure for need base quality requirement. Presently an assessment of volatile oil in selected seed spices *viz*., cumin (*Cuminum cyminum* L.), fennel (*Foenicum vulgare* M.), and coriander (*Coriandrum sativum* L.) were conducted from collectively 923 samples collected from various sources during the two years 2011-12 and 2012-13 harvested crops. Results showed in table 1 are pooled average volatile oil (VO) content (v/w%) in seed spices that were found to be 4.10 $\pm$ 0.825%, 1.69 $\pm$ 0.525%, and 0.46 $\pm$ 0.125% from 326, 337, and 260 samples of cumin, fennel and coriander, respectively. In cumin and fennel seed from agronomic trials showed highest volatile oil 4.79% and 2.02%, whereas processed seed powder showed lowest volatile oil of 3.50% and 1.44%, respectively, in both crops. While in case of coriander, the VO value was 0.48% as highest in breeding trial samples, but at par with rest of collection from APMCs & FLD's, agronomic trials, and pooled average value at 0.46%. Crops of cumin and fennel seed from organic farming were significantly at par with agronomic trialed, whereas breeding- a varietal diverse cumin and fennel seed shows significant lower VO at 3.76% and 1.68% than rest collections of crops, respectively, in pooled value of both years. The volatile oil average values in cumin and fennel were 4.04%, 4.16% and 1.54%, 1.84% of their respective year of 2011-12 and 2012-13, which were within the significant limit but processed sample lead to decreases the content significantly from 4.10 $\pm$ 0.825% to 3.50 $\pm$ 0.59% which is net 17.14 percentage less than that of the pooled average value. It may infer from this assessment of volatile oil in cumin, fennel and coriander seeds that the good agricultural production practices as well as organic farming may increase in content against processed-cleaned.

Key words: volatile oil, cumin, fennel, coriander, agricultural practices

Spices are having unique aromatic and flavoring properties due to phytochemical mixture that make then a special ingredient for the culinary as well as salubrious. This special property is due to present of volatile oils (VO) is also known as an essential oils (EO) in it, which are a diverse groups of natural biochemical ingredients in spices and condiment that are important sources of aromatic and flavoring chemicals in food, cosmetic, pharmaceutical and process products. Volatile oils are largely composed of terpenes and aromatic polypropanoid

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compounds derived from the acetate-mevalonic acid and the shikimic acid pathways, respectively (Croteau *et al*., 2000, Alemayehu *et al*., 2016). Essential oil composition and content of plants varies among and within spices, also differ due to genetic and environmental factors that influence genetic expression (Bernath *et al*., 1986).

Essential oils, there can be several reasons why the composition and thus, the EO quality from aromatic plants might differ greatly, which can be due to genetic, physiological and environmental factors as well as processing conditions. *In the genetics,* taxon clone, hybrid, cultivar, population intra specific chemotypes (distinct populations within a species), p*hysiological such as o*ntogenetic developmental changes (vegetative <> generative), plant organ size and morphological differences (root, leaf, flower, seed), *Environmental like c*limate, light hours, temperature, latitude, height above mean see level, origin of spices, continent, agriculture cultivation techniques, fertilizer, irrigation, harvest time, and *pre processing etc.* The essential oil content of plant tissue also varies with developmental stage (Burbott and Loomis, 1967, Lawrence, 2002) and EO can vary by extraction methods, isolation distillation, extraction, maceration, pressing, effleurages, storage effects of aging, ΔT, rH etc. on raw material or EO Adulteration/ Standardization EO blending prior to distillation/ directly into the EO (Guenther, 1972).

The major seed spices produce as a agro commodities in the Gujarat region are cumin, fennel, fenugreek, coriander, ajwain, and dill seed. Cumin, fennel, coriander are major case crops with high value and low volume for farmer of arid and semi-arid region of Gujarat and Rajasthan in India. Cumin, coriander required fewer inputs, cultivated in *rabi* season, whereas fennel is long duration cold weather seed spice crop grow during *kharif* and *rabi* season (Panda, 2010)**.** Quality, quantity as well as productivity base cumin, fennel, coriander were prominent in India that make then to export oriented case crop for country too. The share of seed spices export to total spices is only 18 per cent in terms of quantity from Indian spices and spices products that reaches more than 135 countries in world. During last four years export of total spice are increasing value in million US dollar from 2,212 to 2,633 in the year of 2012-13 to 2016-17 (estimated), cumin as third most export product from country at it increased in rupees from lakh 115,306.61 to 196,320.00 and quantity volume from 85,602 to 119,000 tons during same year's period. The total export of spices has exceeded in terms of both volume and value as compared with the target to 8,70,000 tons, valued Rs.15725.12 crore (US$2419.25million) for the financial year 2016-17 the achievement was 109% in terms of volume and 112% in rupee and 109% dollar terms of value (Anonymous 2017). There is a need for clustering of farmers, formulation of cooperatives for international marketing and development sustainable a value addition in the field of spices, a particularly seed spices to enhance self life through value added derive product such as volatile oil, oleoresin and extractant *etc*. and to general more revenue than the presently, particularly during direct seed's marker price slow down with bumper production. Therefore present study was carried out to evaluate the volatile oil content in different seed spices as a one of the most important parameter for spice quality for grading and value addition. To identify the agronomic effort to have high quality seed having maximum vital ingredients that is volatile oil. The objective of the present studies was to determine VO content in three seed spices samples collected from different sources such as agronomic trails, from markets that is APMCs, processed houses, organic

farming FLD's, breeding trails as well as pool together to ascertain a source of quality crops produce, that will useful for need base procurement for specialized marketing or go to value addition.

MATERIALS AND METHODS

Samples:

The investigation of the present studies were conducted for the percent volatile oil (VO) present in selective three seed spices, cumin (*Cuminum cyminum,* L.), fennel (*Foenicum vulgare* Mill), and coriander (*Coriandrum sativum* L.). For the estimation of volatile oil, total 923 samples, out of which 326, 337, and 260 of cumin, fennel, and coriander, respectively, were collected from the different sources Front Line Demonstrations (FLD's) and Agricultural Production Marketing Committees (APMC's), process houses, agronomic trials, organic farming trials, breeding trials experimental at center for research on seed spices (CRSS), Sardarkrushinagar Dantiwada Agricultural University (SDAU), Jagudan-382 710, during successive two year of 2011-12 and 2012-13. Each seed spices samples of 200-250 gram were packed in the polyethylene sealed bags and stored in the refrigeration at 4°C temperatures until analysis.

Volatile oil determination

Volatile oil content was evaluated by hydro distillation (HD) technique with Clevenger-type apparatus as per m*ethod* suggested (ASTA, revised 2010). Seed powdered were prepared quickly in grinding mill passing through no. 20 mesh size sieve and avoid undue heating of sample during grinding, mix carefully to avoid stratification (layering), immediately use for analysis, where weight the accurate 50 gm of grinded seed powder and loaded in the round bottom steam generation flak of 1 liter of Clevenger assembly, powder immersed with 500 ml water enough to submerge sample completely in the steam flask. Steam flask heated gently to allow the distillation for 3-4 hours under cool water circulation in Clevenger condenser and allow to separation of two layers in graduated tube of assembly to measure the reading, calculated and express volatile oil % percent (v/w) and standard deviation (SD) using Microsoft excel program format.

RESULTS AND DISCUSSION

Volatile oil is an essential component of the spices and its content in the seed spices such as cumin, fennel and coriander play a critical role for their quality assessment and to obtain value addition products. Second most important aspects in agricultural research after breeding program of selection of variety is to find out most appropriate agricultural practices on crop of cultivation for maximum yield, productivity and better quality produce. For spices seed quality product is determined based on biochemical constitution properties particularly content of volatile oil present in the final product. The scope of research for quality product during cultivation of crops at various levels such as the improvement of genetic breeding of seeds, the development of high yield and constitute varieties etc at germ plasma level. Second one should be good agricultural practices like geometry, fertilization, protection measures, agronomy and assessment of environmental factors that have significant influences on quality parameters of crop and its products. The processing and post harvest treatment at final level also have functional role in preservation and maintenance of quality of particularly spices seed and its products. Taking into these criteria under consideration, volatile oil of the spices and

spices product play a imperative responsibility to justify its quality and justification of value, therefore determination of volatile oil have been carried out from the various samples of the spices seeds of cumin, fennel and coriander collected from various sources as mention in material and methods.

The results of the volatile oil content in three seed spices, five categories and overall pooled value for the studies of two successive productive year 2011-12 and 2012-13 were shows in the table-1, The pooled samples value of mean volatile oil in per cent and standard deviation (SD) of cumin (326) fennel (337) and coriander (260) were found at 4.10 ± 0.825, 1.69 ± 0.525 and 0.46 ± 0.026%, respectively. Samples analysis from the both the year 2011-12 and 2012-13 crops, resulted values of agronomic practice trials samples of cumin and fennel showed highest volatile oil at 4.77% and 1.94%, 4.80% and 2.10%, respectively, which were significantly highest among all others samples of the same years, followed by organic farming samples had 4.52 ± 0.38% and 1.76 ± 0.18%, 4.70 ± 0.52% and 2.04 ± 0.10% respectively in both years. In case of coriander samples from samples of APMCs,& FLD's, agronomic trials, and breeding trials did not show any significant variation in volatile oil values at 0.48%, 0.47% , and 0.49% in 2011-12, as well as at 0.46%, 0.42%, and 0.46% in year 2012-13, respectively, against average values of 0.44 ± 0.12% and 0.48 ± 0.09% in both respective years.

The volatile oil percent values of the samples of cumin and funnel from CRSS breeding trails had second lowest value 3.64% and 1.66% and 3.87 % and 1.92 %, respectively, than the processed one in both year's crops. Cumin samples from processed category had 3.39% and 3.60% which are lower in year 2011-12 and 2012-13, respectively, in case of fennel had 1.44% as lowest in year 2011-12. Cumin from APMC's & FLD's samples value of 4.04% and 4.00% in the both years, which are at par with average as well as pooled mean values of volatile oil. During both years 2011-12 and 2012-13, organic farming samples had second highest in both crops cumin values as 4.52% and 4.70% and fennel values 1.76% and 2.04%, respectively, which are at par with agronomic trials seed content value of highest. In case of coriander samples average values were found to be at 0.44 ± 0.124 % and 0.48 ± 0.091% in years 2011-12 and 2012-13, respectively, without any significant variability among agricultural trials, APMC's & FLD's, and breeding trials samples.

Samples of cumin and fennel from various sources mentioned in table 1 for volatile oil analysis, pooled value of two consequence productive year 2011-12 and 2012-13 had significant variation among each others. Cumin sample from agronomic trials practice showed highest 4.79% and processed samples have a lowest 3.50%, similarly in fennel agronomic and APMCs & FLD's samples had highest 2.02% and processed have only 1.44%. Pooled mean value of volatile oil of the samples of cumin (236) and fennel (337) and coriander (260) had 4.10%, 1.69% and 0.46%, respectively. As compared with reported by Simon *et al.,* (1984) value of volatile oils found in cumin was essential oil 2.5 to 5 percent on a dry weight basis, whereas seeds of cumin (*Cuminum cyminum* L.) from China was a yield of 3.8%, obtained by steam distillation reported by Rong *et al*., (2004). Thus the cumin in the present studies variety GC-4 cultivated at CRSS, SDAU, Jagudan and other North Gujarat and its vicinity regions had 4.10% which higher end by 15-20% volatile oil percent content as compared with international reported values. The Fennel has reported value of volatile oil content in seed varies considerably

with the variety, being the lowest 0.7- 2.0% in fruits of Indian origin and highest (4-6%) in fruits obtained from Eastern Europe as mention by Joy *et al*., (2001). While the fennel (*Foeniculum vulgare* L.) variety GF 11 cultivated at in this studies have similar 1.70 % VO value to the reported values of 0.7 - 2.0%. Coriander seed the essential oil is obtained by the steam distillation of mature dry larger seed contains very low 0.10-0.35% where as the small seed contains 0.8-1.8%. (Dimiri, 1976) while in present study cultivated coriander (*Coriandrum sativum* L.) Gujarat Cori-2 variety has volatile oil at 0.46% which more than larger seed, but lesser than smaller seed one.

The present studies on volatile oil content in three different seed spices incite that the agronomic practice in both cumin and fennel and some extend organic fertilized farming has more volatile oil content than the farmer practice cultivated pooled samples. Such data may helpful fort the selection of farm practice to improve VO content in seed spices and overall value addition for export oriented spices.

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Table 1 Volatile oil (v/w %) in seed spices estimated from different sources of samples collected during year 2011-12 and 2012-13

Productive period	Year	2011-12		2012-13		Pooled	
Sample type	No.	Mean % VO	No.	Mean % VO	No.	Mean % VO	
Cumin (*Cuminum cyminum* L)							
APMC's & FLD's	70	4.04 ± 0.620^{b}	5	4.00 ± 0.503^{b}	75	4.02 ± 0.562^{b}	
Processed	32	3.39 ± 0.596^{c}	22	3.60 ± 0.347^{c}	54	3.50± 0.472^{c}	
Agronomic trials	26	4.77 ± 0.592^{a}	107	4.80 ± 0.440^{a}	133	4.79± 0.516^{a}	
Organic farming	12	4.52 ± 0.386^{a}	13	4.70 ± 0.520^{a}	25	4.61± 0.453^{a}	
Breeding trails.	19	3.64 ± 0.657^{c}	8	3.87 ± 0.659^{c}	27	3.76± 0.408^{c}	
Average value	159	4.04 ± 0.851^{b}	155	4.16 ± 0.679^{b}	314	4.10 ± 0.825^{b}	
Fennel (*Foeniculum vulgare* M.)							
APMC's & FLD's	00	--	4	2.02 ± 0.251^{a}	4	2.02± 0.105^{a}	
Processed	10	1.44 ± 0.105^{c}	0	--	10	1.44± 0.192^{c}	
Agronomic trials	10	1.94 ± 0.107^{a}	65	2.10 ± 0.176^{a}	75	2.02± 0.191^{a}	
Organic farming	16	1.76 ± 0.179^{a}	41	2.04 ± 0.103^{a}	57	1.88± 0.355^{a}	
Breeding trails.	166	1.66 ± 0.158^{b}	24	1.92 ± 0.159^{b}	190	1.68± 0.331^{b}	
Average value	202	1.54 ± 0.284^{b}	134	1.84 ± 0.278^{b}	336	1.69 ± 0.525^{b}	
Coriander (*Coriandrum sativum* L.)							
APMC's & FLD's	08	0.48 ± 0.082^{a}	10	0.46 ± 0.035^{a}	18	0.47± 0.059^{a}	
Agronomic trials	20	0.47 ± 0.059^{a}	29	0.42 ± 0.059^{a}	49	0.45± 0.059^{a}	
Breeding trails.	180	0.49 ± 0.083^{a}	23	0.46 ± 0.072^{a}	203	0.48± 0.123^{a}	
Average value	208	0.44 ± 0.124^{a}	62	0.48 ± 0.091^{a}	270	0.46 ± 0.026^{a}	

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Feed conversion efficiency in early lactating Kankrej cattle at organised farm

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ABSTRACT

A study was conducted to investigate feed conversion efficiency in early lactating Kankrej cattle at Livestock Research station, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar. The variables such as average dry matter intake, milk yield and milk composition were evaluated in forty nine lactating Kankrej cows over the period of 30 days. The mean dry matter intake was 9.71±0.08 kg/d. The average milk yield and energy corrected milk were 12.45±0.35 and 14.27±0.47 kg/d, respectively. Feed conversion efficiency was 1.48±0.05 in Kankrej cows.

Key words: Dry matter intake, Feed conversion efficiency, Kankrej cow, Milk yield

The economic potential of livestock mainly depends upon feed conversion efficiency of the animals. Feed conversion efficiency is a simple measure to determine the relative ability of animal to turn feed nutrients into milk and/or milk components. Feed conversion efficiency is the kilograms of milk produced per kilogram of dry matter intake. For livestock products, about two-thirds of this increased demand will need to be met by improving the production efficiency of feed, both forages and concentrate feeds (FAO, 2012). The monitoring of feed efficiency has become not only an economic marker in dairy farming, but also an excellent environmental marker (Hutjens, 2010). Moreover, feed conversion efficiency is receiving more attention as feed costs have increased. Feed efficiency is highly variable among dairy cows and this variation can have a significant impact on economic performance (Linn *et al*., 2009). Feed conversion efficiency also has implications for environmental concerns. If diary animals can more efficiently convert feed into milk, then less manure volume and manure nutrients should be produced. High feed conversion efficiency (> 2.0) in early lactation can actually indicate a problem that animals are losing too much weight, possibly leading to metabolic disorders. Moreover, in an FAO (2012) symposium (Makkar and Beever, 2013) and several authors highlighted the importance of characterizing dairy production systems with a focus on feed efficiency.

Kankrej is one of the dual purposes indigenous breed of India having home-track in north Gujarat, which is good for milk production and bullocks are very powerful/ strong and suitable for draft purpose. During the year 2017 average lactation milk yield of Kankrej cow was 2523.33 litres in 305 days at Livestock Research Station, Sardarkrushinagar (Anonymous, 2018). However, information about feed conversion efficiency in lactating Kankrej cow is very meager. Therefore, this study was conducted with the aim to estimate the feed conversion efficiency in early lactating Kankrej cows at Livestock Research Station, Sardarkrushinagar.

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MATERIALS AND METHODS

The experiment was carried out at Livestock Research Station, Sardarkrushinagar. Forty nine lactating Kankrej cows (21 days after calving) were used in this experiment for 30 days. The animals were fed as per ICAR (2013) feeding standards to meet the nutrient requirements. Cows were fed with fixed quantity of concentrate pellets and cotton seed cake along with measured amounts of green and dry fodder. Left over was recorded daily. All the experimental animals were reared under standard management practices with free access to fresh and clean drinking water. The feeds and fodder used in the experiment were analyzed for chemical composition *viz.* dry matter, crude protein, crude fiber, ether extract and total ash (AOAC, 2007).

All cows were milked twice a day (morning 4:00 a.m. and evening 4:00 p.m.) and individual milk yield and milk constituents of each cow were recorded daily. Milk fat, solid not fat (SNF), protein and lactose were determined by using EKOMILK Ultra Pro Milk Analyzer (Everest Instruments Pvt. Ltd.). The energy corrected milk (ECM) yield was calculated as:

ECM = 0.327 x Milk yield (kg) +12.95 x Fat yield (kg)+7.20 x Protein yield (kg)

Feed efficiency was calculated as:

Feed efficiency was calculated as: ECM/(Dry matter intake (kg))

RESULTS AND DISCUSSION

The chemical composition of feeds and fodders fed to experimental animals is given in Table 1. The crude protein content in pellet feed, cotton seed cake, green maize and jowar hay was 18.59, 22.44, 5.37 and 4.20%, respectively.

Table 1 Chemical composition (on % DM basis) of feeds and fodders

Parameters (%)	Concentrate Pellet	Cotton Seed Cake	Green Maize	Jowar Hay
Moisture	4.45	6.11	84.4	10.20
Crude protein	18.597	22.44	5.37	4.20
Crude fibre	6.58	10.43	32.53	32.3
Crude fat	2.43	5.75	1.42	1.40
NFE	64.15	54.01	51.11	53.30
Total ash	8.25	7.37	9.57	8.80

Various milk parameters in lactating Kankrej cows presented in Table 2. The overall mean dry matter intake was 9.71±0.08 kg/d. Similarly, Raval *et al.,* (2013) reported average dry matter intake of 10.03±0.04 kg/d in lactating Kankrej cows. The average milk yield and energy corrected milk were 12.45±0.35 and 14.27±0.47 kg/d, respectively. Feed conversion efficiency was 1.48±0.05 in Kankrej cows. Vallimont *et al.,* (2011) and Arndt *et al.,* (2015) reported feed conversion efficiency of 1.03 and 0.98, respectively in commercial dairy farms. As all the cows were in peak lactation, we found better milk yield and feed efficiency in Kankrej cows. Moreover, high yielding animals are more energetically efficient, since the most part of the ingested energy is diverted to the mammary gland for production of milk, in relation to maintenance (Linn *et al.,* 2007). The average fat content in Kankrej cow milk was 4.08±0.09%. Earlier studies also reported similar range of fat percentage in Kankrej cow milk (Patel *et al.,* 2017; Joshi *et al.,* 2018).

Table 2 Feed intake and various milk parameters in early lactating Kankrej cows (n=49)

Sr No.	Parameters	Mean±SE
1	Dry matter intake (kg/d)	9.71±0.08
2	Average milk yield (kg/d)	12.45±0.35
3	Energy corrected milk (kg/d)	14.27±0.47
4	Feed conversion efficiency	1.48±0.05
5	Milk fat (%)	4.08±0.09
6	Milk SNF (%)	8.24±0.08
7	Milk lactose (%)	4.39±0.04
8	Milk protein (%)	3.34±0.03

CONCLUSION

By above study, it is concluded that feed conversion efficiency at second month of lactation in Kankrej cattle was 1.48 at Livestock Research Station, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat.

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