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Entrepreneurship Opportunity and Challenges in Finger Millet Processing

R. V. Powar [1] and V. V. Aware[2]

ABSTRACT

Traditionally, the threshing, pearling and cleaning operation of finger millet (FM) is performed manually. It characterized as low output, time-consuming, laborious and uneconomical. Also, to get finished grains from FM panicles one-time threshing, one time pearling and two times cleaning operation are needed. To overcome this problem a 2 hp single-phase electric motor operated finger millet thresher-cum-pearler (FMTCP) was developed, that perform all respective operations in a single pass. The feed rate of developed FMTCP is 36 kg h^{-1}. Its performance was carried out as per IS:6284-1985 test code and economic analysis were done by IS:9164-1979 test code. Manually, threshing capacity, pearling capacity, cleaning capacity after threshing and cleaning capacity after pearling were found as 24.3 kg h^{-1}, 11.23 kg h^{-1}, 11.6 kg h^{-1} and 9.1 kg h^{-1}, respectively. The benefit-cost ratio and payback period were found as 7.25 and 10.80 months, respectively. The operating cost and energy consumption of FMTCP was 84 and 44 per cent less than that of manual processing of FM, respectively. It overcomes the limitations associated with manual processing of FM such as low output, laborious, time-consuming and cost of operation. The cost of FMTCP can be recovered within 10.80 months. Considering easy handling, ease of operation and good performance the developed FMTCP can be a solution for mechanized finger millet processing.

Finger millet *(Eleusine coracana* (L) Craertn) commonly known as *Ragi*, is one of the important small millet crop grown in red soil areas of India. It is popularly called as *Nachni* (dancer) in the state of Maharashtra. The popularity of FM is due to its high nutritional and medicinal value. It is rich sources of fiber, calcium, amino acid, iron and sulfur. High fiber content permitting the slow digestion process that popular in diabetic patients. Also, it lowers the appetite, helps to control weight by keeping away from taking excessive calories, give a feeling of fullness that controls the excessive food consumption, bringing down the cholesterol level by eliminating excess fat from the liver and maintain the blood pressure (Ushakumari *et al,.* 2009; Shobana *et al.*, 2011; Gull *et al.*,2016). Calcium richness helps strengthen the bones, treat anemia and revert the skin aging.

The FM crop occupies an area of 2.5 Mha and contributes 2.6 Mt of grain production in India (Department of Agriculture, Government of Maharashtra, 2019). The average yield of the crop under rainfed conditions is 1000 kg ha^{-1} and under irrigated conditions, it is 2500 kg ha^{-1}. The state-wise productivity of FM was 1062 kg ha^{-1} in Maharashtra, 952 kg ha^{-1} in Andhra Pradesh, 1871 kg ha^{-1} in Karnataka, 562 kg ha^{-1} in Orissa, 2715 kg ha^{-1} in Tamil Nadu, 1392 kg ha^{-1} in Uttrakhand with 1641 kg ha^{-1} average of India in the year 2015-2016. In Maharashtra state, the FM crop cultivated on 92000 ha area having total production of 93000 tonnes. The coastal districts of Maharashtra viz. Thane, Palghar, Raigad, Ratnagiri, and Sindhudurg are leading districts for FM production. Also, few districts from western Maharashtra viz. Nasik, Pune, Satara, and Kolhapur are popular for FM cultivation and production. The highest area under FM crop in Nasik district followed by Kolhapur, Ratnagiri and Palghar district. While the Sindhudurg (1628 kg ha^{-1}) district had the highest productivity followed by Ratnagiri (1189 kg ha^{-1}) and Kolhapur (1311 kg ha^{-1}). Similarly, the highest production of FM was seen in Kolhapur district followed by Nasik and Ratnagiri district (Annonymous, 2019).

The harvesting of FM crop is done at physiological maturity at 16-20 per cent MC, after that the crop sun-dried to reduce its moisture up to 10-12 per cent and then stacked for 1 to 1.5 months to lose the grains and glumes from the crop panicles (Singh *et al.*, 2015). Traditionally in India, the threshing of FM is performed by different methods such as manually beating with sticks, bullocks-drawn stone roller, and tractor-drawn stone roller.

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These methods are characterized as laborious, low output, uneconomical, low-quality product, a hygienic operation and low germination percentage of grains. Similarly, the pearling operation of FM is performed by different methods such as rubbing grain in a gunny bag, leg pounding andstone grinding (*Jatta*) (Singh *et al.*, 2002; Pradhan *et al.*, 2010; Joshi *et al.*, 2015). Considering the above points, the FMTCP was designed that perform all operations viz. threshing, pearling and cleaning in a single pass with better performance. The paper highlights the entrepreneurship opportunity and challenges in finger millet processing.

MATERIAL AND METHODS

Finger millet thresher-cum-pearler

The major components of developed FMTCP were a threshing drum, pearling drum, and cleaning unit (sieve walker and blower) (Fig. 1). The threshing drum consists of a threshing cylinder, concave, threshing sieve and outer casing. The threshing cylinder was made of 16-gauge thickness mild steel (MS) sheet having diameter 200 mm and length 300 mm. (Powar *et al.*, 2018). Threshing sieve was made of 16-gauge thickness MS sheet having 2 mm holes with a length 300 mm and projected width 60 mm.It was fitted in the open space provided at the lower part of threshing drum. The threshing sieve had circular openings (2 mm, f)The optimum operating conditions of threshing drum i.e.feed rate, concave clearance, and drum speed were found as 36 kg h^{-1}, 5 mm and 7.11 m/s, respectively with 99 per cent threshing efficiency, 86 per cent pearling efficiency and 0.1 % grain damage (Powar *et al.,* 2019[a] Powar *et al.,* 2019[d]). The detail construction and optimization of operational parameters of threshing drum are given in the cited article of Powar *et al.* (2019[a]). Pearling drum consists of pearling cylinder, concave, pearling sieve and outer casing. The pearling drum was developed to meet the capacity of the threshing drum. The diameter and length of the pearling cylinder are 200 mm and 180 mm, respectively. It was made of MS sheet of 16-gauge thickness. The opening of lower concave was for fixing threshing sieve while that of upper concave was for fitting feeding duct. The optimum operating conditions of pearling drum i.e. drum speed, concave clearances, and pearling sieve size were 7.25 m/s, 3 mm and 2 mm, respectively with 99 per cent pearling efficiency and 0.5 per cent grain damage (Powar *et al.,* 2019[b]). The detail construction and optimization of operational parameters of the pearling drum are given in the article by Powar *et al.* (2019 [b]).The cleaning system was also designed to meet the capacity of thresher-cum-pearler. It consists of sieve walker and blower. The heavy straw particles are removed by sieve walker and bran is removed by the blower. The sieve walker made of a rectangular sieve of 250 mm × 375 mm dimension with 2 mm sieve size. The sieve was placed on MS angle frame with 3.5° horizontal slope. The impeller was made up of four blades each of size 180 x 60 mm. All the four blades were mounted on the periphery of a hub of 30 mm diameter at 90° apart. The optimum operating conditions of cleaning unit i.e. sieve slope, stroke length and frequency of stroke were found as 3.5°, 20 mm and 400 strokes min^{-1}, respectively with 97.27 per cent cleaning efficiency and 1.26 per cent spilled grain (Powar *et al.,* 2019[c] and Powar *et al.,* 2022). The detail construction and optimization of operational parameters of the cleaning system are given in the cited article by Powar *et al.* (2019[c]). Feeding hopper was constructed as per guideline is given by IS:9020-1979 (Safety requirement). MS sheet of 16-gauge thickness was used for the fabrication of hopper. The total length and width of the chute were 900 mm and 200 mm, respectively. The angle of inclination of a hopper with horizontal was 10 degree. The mainframe supported the whole assembly including hopper, threshing drum, pearling drum, cleaning unit and electric motor. The frame was made with MS angle of size 40 mm × 5 mm. The overall height, width, and length of the frame were 825 mm, 550 mm and 650 mm, respectively (Table 1).

Fig. 2 Finger millet thresher-cum-pearler

Table 1 : Specification of FMTCP

S.N.	Parameter	Specification
A)	Threshing drum	
1	Diameters, mm	200
2	Length, mm	300
3	Thickness of canvas support (M.S flat plate), mm	3
4	Concave clearance, mm	5
5	Threshing sieve size, mm	2
B)	Pearling drum	
1	Diameters, mm	200
2	Length, mm	180
3	Thickness of canvas support(M.S flat plate), mm	3
4	Concave clearance, mm	3
5	Threshing sieve size, mm	3
C)	Sieve Walker	
1	Length, mm	375
2	Width, mm	250
3	Height, mm	222
D)	Blower	
1	No of fan blades	4
2	Impeller diameter, mm	180
3	Impeller length, mm	180
E)	Diameter of shafts	
1	Threshing cylinder, mm	25
2	Pearling cylinder, mm	25
3	Blower, mm	15
4	Reciprocating mechanism, mm	15
F)	Main frame	
1	Height, mm	825
2	Length, mm	650
3	Width, mm	550
G)	Overall dimensions of machine	
1	Height, mm	1250
2	Length, mm	1159
3	Width, mm	710

Performance evaluation of finger millet thresher-cum-pearler

The performance parameters viz. threshing efficiency, pearling efficiency, cleaning efficiency and total grain loss (Grain damage + spilled grain) were measured by using the following expressions.

Threshing efficiency

Threshing efficiency is the ratio of the quantity of unthreshed grains obtained from all outlets per unit time to the quantity of total grain input per unit time. It was calculated by Eq. 1.

$$\eta_{\lambda} = \left(1 - \frac{Wup}{Wtp}\right) \times 100 \quad \ldots (1)$$

where,

η_{λ} = threshing efficiency, %;

w_{up} = weight of unthreshed panicles, g;

w_{tp} = weight of total panicles feed per unit time, g.

Pearling efficiency

Pearling efficiency was calculated by counting the number of un-pearled grains from 100 grains collected from the main grain outlet using Eq. (2).

$$\eta_{p} = (100 - N_{up}) \quad \ldots (2)$$

where,

η_{p} = pearling efficiency, %; and

N_{up} = number of un-pearled grains.

Cleaning efficiency

Cleaning efficiency is the ratio of total clean grain collected from main grain outlet per unit time to the total grain with impurity collected from the main outlet per unit time. It was calculated by using Eq. (3).

$$CE = \left(\frac{w_{cg}}{w_{tg}}\right) \quad \ldots (3)$$

where,

CE = cleaning efficiency, %;

w_{cg} = weight of clean grain, g; and

w_{tg} = weight of total grain plus impurity, g.

Total grain loss

Total grain loss is the addition of spilled grain and damaged grain. The details regarding spilled grain and grain damage are given below.

Spilled grain

The spilled grain is the quantity of grain overflow from the cleaning sieve. It was calculated by taking the ratio of the quantity of clean grains collected from the overflow of sieve per unit time to the total quantity of clean grains collected from the main grain outlet per unit time. It was calculated by using Eq. (4).

$$SG = \left(\frac{w_{og}}{w_{cg}}\right) \times 10 \quad \ldots (4)$$

where,

SG = spilled grain loss, %;

w_{og} = quantity of clean grain collected from sieve overflow per unit time, g;

w_{cg} = quantity of clean grains collected from the main outlet per unit time, g.

Grain damage

Grain damage is the ratio of the quantity of damaged grains collected from main outlets per unit time to total grains input per unit time. It was calculated by using Eq. 4.

$$GD = \left(\frac{w_{dg}}{w_{tg}}\right) \times 100 \quad \ldots (5)$$

where,

GD = grain damage, %;

w_{dg} = damaged grains collected from main outlets per unit, g;

w_{tg} = total grains input per unit time, g.

Performance evaluation of traditional methods of FM processing

The performance evaluation of the traditional method of FM processing in Ratnagiri district was studied. The 'Dapoli 1' variety was selected for the experiments. The data collected from the three different locations of Ratnagiri district with different skilled workers. The MC of FM panicles at the time of testing was 8 per cent (db.). Traditionally the threshing of FM is done by beating with a wooden stick, pearling by hand pounding method and cleaning by hand winnowing method. The amount of work done within one hour in each process was noted.

Techno economics analysis of FMTCP

The operating cost of FMTCP was determined by using IS:9164-1979 test code. The cost analysis was carried out based on fixed cost and variable cost. Table 2 represent the material required for fabrication of finger millet thresher-cum-pearler.

Table 2 : Cost of fabrication for finger millet thresher cum pearler

S. N.	Material	Specifications	PriceRs.
1	M.S Metal sheet	19 gauge, 8*4 feet	1401
2	M.S Angle	50*50*4mm: 2 No	1681
3	M.S Polish shaft	f25mm, 800 mm length	1009
4	M.S Metal pipe	f120 mm * 400 mm	504
5	Bearing UCP 205	8 No	3139
6	M.S Polished bar	6 mm*6 No	672
7	M.S Flat plate	25*3, 1 No	448
9	M.S Thick plate	15 mm thick , f168 mm, 4 No	896
10	M.S Thick plate	8 mm thick , f226 mm, 4 No	1121
11	Pulley 8 no	4"*2, 3.5"*2, 6"*2, 9"*1, 3"*1	2186
12	Ground wheel with shaft	4 No	672
13	Perforated sheet	2 mm, 3mm, 4mm: 8 sq feet	1345
14	V belt	4 No	1345
15	Canvas belt	50mm*4 mm: 30m	2242
16	Nut bolt	2 kg	224
17	2 hp single phase motor	1 No	5600
18	Total Material cost	18885	
19	Fabrication cost, (50 % of material cost)	9442	
20	Purchased items	448	
21	Total cost of machine	28775	

Techno-economics analysis of finger millet thresher-cum-pearler

Net present worth (NPW)

The NPW is defined as the difference between present worth of savings and cost of investment. The mathematical statement for net present worth given Eq. (6).

$$NPW = \sum_{t=1}^{t=n} \frac{B_t - C_t}{(1+i)^t} \quad \text{....(6)}$$

Where,

Ct = Cost in each year,

Bt = Benefit in each year,

t = 1, 2, 3...n, i = discount rate

Benefit – cost ratio

This ratio was obtained when the present worth of the benefit stream was divided by the present worth of the cost stream. Mathematically it expressed as Eq. (7).

$$= \frac{\sum_{t=1}^{t=n} \frac{B_t}{(1+i)^t}}{\sum_{t=1}^{t=n} \frac{C_t}{(1+i)^t}} \quad \text{....(7)}$$

Payback period

The payback period refers to the amount of time it takes to recover the cost of an investment.

RESULTS AND DISCUSSION

Performance of finger millet thresher-cum-pearler

The developed FMTCP shows the threshing efficiency, pearling efficiency, cleaning efficiency and total grain loss of 99.51 $\pm$ 0.11 per cent, 98.22 $\pm$ 0.31 per cent, 96.51 $\pm$ 0.25 per cent and 2.35 $\pm$ 0.07 per cent, respectively at moisture content (MC) 10 per cent (db).

Performance evaluation of traditional processing methods of FM

The performance evaluation of the traditional processing of FM was studied at three different locations in Ratnagiri district with different workers. Traditionally FM threshed by beating with a wooden stick, pearled by hand pounding method and cleaned by manual winnowing. The traditional FM processing was performed by one-time threshing, one time pearling and two times cleaning operation (one after threshing and one after pearling operation). The mean threshing capacity pearling capacity, cleaning capacity after threshing and cleaning capacity after pearling were found as 24.3 kg h^{-1}, 11.23 kg h^{-1}, 11.6 kg h^{-1} and 9.1 kg h^{-1}, respectively (Table 3). Considering the above results it was found that the daily (8hrs working) one worker can process 24.5 kg finger millet. The output capacity of FMTCP is 27 kg/h (input finger millet panicles 36 kg h^{-1} × grain straw ratio, 0.75). It can process 196.56 daily (8 hrs working) considering operational efficiency (91-92 %). Therefore, the performance of the FMTCP is eight times higher than of the manual process and it can save daily eight workers. This finding revealed that the traditional methods of FM processing were time-consuming, labor-intensive, low output and drudgery prone.

Techno-economic analysis of FMTCP

Table 2 shows that the material required for fabrication of FMTCP. The cost of the machine was Rs. 28775/-. Table 9 and 10 shows the detail income and expenditure of FMTCP. To determine the operating cost of thresher-cum-pearler the fixed cost and variable cost of the machine were considered. The fixed cost and variable cost of FMTCP were found at 8.22 Rs. hr^{-1} and 34.38 Rs. hr^{-1}, respectively. Therefore, the total operating cost of FMTCP is 42.60 Rs. hr^{-1} and the total operation and maintenance cost for 1 year is Rs. 25431/-. The threshing, pearling and cleaning operation cost for 1000 kg FM grains by developed FMTCP and the traditional method was 1412.63 and 8871.93 (Table 4). Therefore, it proved that the operating cost of FMTCP was 84 per cent less than that of the traditional processing of FM. The net present worth, benefit-cost ratio and payback period were found as Rs. 496675, 575 and 10.80 months, respectively (Table 5, 6 and 7). In the Konkan region of Maharashtra, (India) yearly two seasons of FM were taken. Therefore, within one year the cost of the machine is possible to recover.

CONCLUSION

The developed finger millet thresher-cum-pearler was successfully operated by 2 hp single-phase electric motor performing all operations pertaining to finger millet processing viz. threshing, pearling and cleaning satisfactorily, in a single pass with clean grains output 27-30 kg h^{-1}. It showed the higher threshing efficiency, pearling efficiency, cleaning efficiency and total grain loss of 99.51 per cent, 98.22 per cent, 96.51 per cent and 2.35 per cent, respectively at moisture content 10 per cent (db). The manual threshing capacity, pearling capacity, cleaning capacity after threshing and cleaning capacity after pearling were found as 24.3 kg h^{-1}, 11.6 kg h^{-1}, 11.23 kg h^{-1} and 9.1 kg h^{-1}, respectively. Manual processing capacity of FM was eight times less than that of the FMTCP. The operating cost and energy consumption of FMTCP was 84 per cent and 44 per cetnt less than that of manual processing of FM, respectively. It overcomes the

Table 3 : Traditional performances of FM processing

S.N.	Location	Range				Mean			
		TC, Kg h^{-1}	CCAT, Kg h^{-1}	PC, Kg h^{-1}	CCAP, Kg h^{-1}	TC, Kg h^{-1}	CCAT, Kg h^{-1}	PC, Kg h^{-1}	CCAP, Kg h^{-1}
1	Dapoli	23.5-24.6	10-12	10-12	8- 9	24.2	11.5	11.5	8.6
2	Khed	24.5-25	11.5-12.8	9-10	9.5 -10	24.80	11.9	10.5	9.8
3	Kumbhave	23-24.5	11-12	11-12	8.5-9	23.9	11.4	11.7	8.9
	Average					24.3	11.6	11.23	9.1

TC: Threshing capacity, PC: Pearling capacity, CCAT: Cleaning capacity after threshing, CCAP: Cleaning Capacity after pearling

Table 4 : Detail of expenditure of FMTCP

S. N.	Particulars	Cost
1	Total cost of finger millet thresher cum pearler, Rs.	28776
2	Fixed cost of finger millet thresher cum pearler, Rs. per h	8.22
3	Variable cost finger millet thresher cum pearler, Rs. per h	34.38
4	Total operating cost of FMTCP Rs. per h	42.60
5	Threshing, pearling and cleaning operation cost for 1000 kg finger millet by developed thresher cum pearler Rs.	1412
6	Threshing, pearling and cleaning operation cost (Rs.) for 1000 kg finger millet by traditional methods, considering wages @ Rs. 217.50 per day.	118
7	Comparative cost of FMTCP with traditional method of processing is less than %.	8871

Table 5 : Detail income of FMTCP

S. N.	Detail	Value
1	Annual use of thresher cum pearler, h	600
2	Initial Investment, Rs.	28828
3	Total operation and maintenances cost for 1 year, Rs.	25432
4	Income from thresher, considering Rs.3.21 per kg grains processing charges, Rs.	97814

Table 6 : Payback period of FMTCP

Year	Present Worth of total cash outflow in 10 years (Rs.)	Cash inflow, Rs.	Present Worth of cash inflow, Rs.	Cumulative cash inflow, Rs.
0	79391.48	Nil	Nil	Nil
1	Nil	97814.76	88121.41	88121.41
				Payback period = 10.80 month

Table 7 : Economic indicator for FMTCP

S. N.	Economic indicator	Values
1	Net present worth, Rs.	496675.87
2	Benefit cost ratio	7.25
3	Payback period (month)	10.80

limitations associated with manual processing of FM such as low output, laborious, time-consuming and cost of operation. The cost of FMTCP can be recovered within 10.80 months. Considering easy handling, ease of operation and good performance the developed FMTCP can be a solution for mechanized finger millet processing.

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An Analysis of Socio-Economic Profile and Enterprise Management Skills of Women Entrepreneurs

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ABSTRACT

To boost up Agro-Entrepreneurship in rural areas it is crucial to focus on women entrepreneurship development in view of feminization of agriculture. Further agriculture-based value-added technologies are native to India's rural areas and women plays vital role in upkeeping these through ages. Thus, women owned food processing enterprises contribute significantly to enhance rural business environment. The present study was conducted in Vaishali district of Bihar to analyse the socio-economic background of the women entrepreneurs in rural areas mostly engaged in several agriculture produce based enterprises with the aim to understand what factors motivate them to start up and run enterprises and to know how efficiently they manage them. In this study ex post facto research design was used and a total number of hundred women entrepreneurs were selected as sample. A survey schedule was designed to analyse the socio-economic profile and general characteristics of the enterprises run by women entrepreneurs. To assess their managerial skills, following a thorough review of the literature, five indicators were selected, each consisting of a relevant questionnaire. The study shows that majority of women entrepreneurs were below the age of thirty five years, having education up to Matric and Inter level and belongs to backward caste community. They preferred to start their enterprise at the small scale with low profit. The main purpose of starting enterprise for majority of the respondents was to provide financial support to their families as their male partners were either unemployed or in business. The findings suggest that the women owned enterprises can be characterized as "self financed" and "self managed".

Agriculture development must be prioritized in order to boost the Indian economy as it is a major source of employment. The long term and sustainable way is agri entrepreneurship incorporating technology and innovation. Development of agriculture, Rural society and entrepreneurship necessitate a special focus on rural women, whose participation is critical to efficiently achieving the goal. Despite providing all necessary assistance and promoting a business-friendly environment, encouraging women to pursue entrepreneurship necessitates a special focus on their qualities and attributes that are often overlooked in the family and society. To promote rural women entrepreneurship after following proper skill training and financial assistance, various research findings indicated that there are still many challenges like providing incubation centers, venture capital funds, as well as enhancing the traits for becoming bankable entrepreneurs beyond the support of family and society. In order to promote the sustainability of women-owned enterprises, it is critical to continuously observe and understand the need for, and factors influencing, women's behaviour in establishing and managing enterprises. The current study aims to take into account all of these factors and aims at

* To analyze the socio-economic factors influencing women entrepreneurs
* To study general characteristics of the enterprises run by women entrepreneurs.
* To understand their Enterprise management skill

MATERIAL AND METHODS

For the present study the "ex-post facto" research design was used. The Vaishali district of Bihar was selected intentionally for this purpose. Out of the total sixteen blocks four blocks namely Biddupur, Mahua, Jandaha and Hajipur were selected randomly. Twenty five women entrepreneurs from each block through snowball technique were chosen thus a total number of hundred women entrepreneurs constituted as a sample for the

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study. Data was collected through a pre-tested schedule followed by a personal interview method then analyzed statistically for frequency, percentage and mean score.

RESULTS AND DISCUSSION

Socio economic profile of women entrepreneurs was studied under the heading personal characteristics, their husbands education and occupation and the family characteristics.

Socio-economic profile of women entrepreneurs

The socioeconomic background of selected women entrepreneurs was investigated in terms of their age, caste, marital status, self-education, membership in social-political institutions, Cosmopolite and modes of communication and transportation. The compiled data has been presented in Table 1.

Age

The pooled data indicated that majority (64 %) of the respondents were young entrepreneur belonging to the age group of up to 35 years followed by 28 per cent of respondents in middle age group and a very low percentage of the respondents that is 8 per cent in old age group. The finding very well explains that Entrepreneurship necessarily requires a high level of dynamism. Young and middle-aged women entrepreneur members may be proactive in the establishment of a business. Young people are primarily interested in taking risks and learning new things in their lives, which is

Table 1: Personal Characteristics of Women Entrepreneurs

S.N.	Variables	Category	Frequency (n=100)	Percentage
1.	Age	Young (Upto 35 years)	64	64
		Middle (36-50 years)	28	28
		Old (Above 50 years)	8	8
2.	Caste	Forward	27	27
		Backward	65	65
		Schedule Caste	8	8
3.	Marital Status	Unmarried	12	12
		Married	80	80
		Widow	8	8
4.	Education	Illiterate (No formal education)	8	8
		Low (Upto 8th Std.)	38	38
		Medium (Matric & Inter)	36	36
		High (Graduation & above)	18	18
5.	Social participation	No membership	52	52
		Membership of one organization/official position or village leaderInvolved in community work	24	24
		without any position	24	24
6.	Cosmopoliteness	Low (Upto 10)	22	22
		Medium (11-20)	60	60
		High (21-30)	18	18
7.	MMeans of transport	No facility	84	84
		Common vehicle for family	12	12
		Own vehicle	4	4

essential for entrepreneurship. Further more, middle-aged women with established family networks and a desire to earn money to support their families, financial pressures may have prompted them to establish the enterprise. This finding has conformity with the findings of Hina (1990), Anna (1990); Nigam (1994); Mishra and Bal (1998); Prasad and Rao (1998) and Bhatia *et al.* (1999) i.e. maximum women entrepreneur were in the age-group of 30-40 years. The findings reported by Husain and Nair (2006), Preethi (2011), Naik *et al.* (2012), Bhagyasree (2014) and Mubeena (2017) support the majority of women entrepreneurs in middle age group.

Caste

Majority of the respondents (65 %) belonged to Backward Caste whereas 27 per cent of the respondents from Forward category while only 8 per cent of the respondents belong to Schedule Caste. This finding supported by Selvaraj N (2015).

Marital Status

Data clearly shows that most of the respondents (80 %) were married followed by 12 per cent unmarried respondents and rest of 8 per cent respondents were widow. Nigam (1994), Kapoor (1998), Prasad and Rao (1998), Ganesan (1999) all support the above findings that the majority of women entrepreneurs were married. This support the idea that married and settled women appeared to be the target source for becoming women entrepreneur. Variables like family support, social status, a better future for their children, and self-achievement undertaken by women were all strongly influenced by women's marital status.

Education

Education plays Vital role in the performance of an entrepreneur as a major source of confidence and inspiration towards enterprise establishment. Table 1 revealed that 38 per cent of the respondents having low educational level followed by 36 per cent of the respondents having medium educational level and only 18 per cent of the respondents having higher education. The finding supported by Vashishta and Kunwar (2005), Vinay (2009), Sharma *et al.* (2012), Ram *et al.* (2013), Patil (2013), Kondal (2014) and Mubeena (2017)

Social Participation

Social participation influenced by the nature of work of respondents. More than half of the respondents (52 %) were not having membership of any social and political organization. However, equal number of respondents (24 %) were in both group as having membership at one organization/village leader and involved in community work without any membership.

Cosmopoliteness

It is the degree of outside contact of the respondents. As evident from table majority (60 %) of the respondents fell under the medium cosmopoliteness categories followed by 22.00 per cent respondents with low cosmopoliteness and only 18 per cent fell under high cosmopoliteness category. This finding was similar with the finding of Bharathamma (2005), Gurubalan (2007), Chidananda (2008), Shekle *et al.* (2013) and Parmar (2014) which shows medium level of social contact for majority of the respondents.

Means of transport

Communication and means of transport for women entrepreneur influence their mobility and entrepreneurial management task performance. As evident from the data that maximum number of respondents (84 %) were not having any common vehicle for their family followed by 12 per cent of the respondents having common vehicle for their family and rest of only 4 per cent owned their own vehicle.

Education and Occupation of Husband

Keeping in view the impact of education on changing behavior, education of both, respondents and their husbands were measured. Table 2 revealed that majority of the women entrepreneurs husband having education up to matric and Inter level followed by 32 per cent of their husbands having low level of education. Further equal number of respondents and their husbands were illiterate whereas 19 per cent of their husbands having higher education.

On the basis of occupation respondents husband were classified into four categories as unemployed agriculture, business and service. The observations shows

that majority of the respondents husbands (44 %) occupation was business, 10 per cent were in service and 5 per cent were in agriculture whereas 41 per cent were unemployed. The finding reveals that Unemployment, a medium level of education for husbands, and husbands engaged in business activities all encourage women to take a risk and start their own business for financial security.

Land Holding

On the basis of size of land holding the respondents were classified into only two categories land less and having marginal holding upto 1 hectare The observation shows that majority of the respondents (63%) were land less. However the rest of 37 per cent of the respondents having marginal land upto 1 hectare. Size of land holding play an important role in the involvement of

Table 2 : Education and Occupation of Women Entrepreneur's Husband

S.N.	Variable	Category	Frequency (n=100)	Percentage
1.	Education	Illiterate (No formal education)	8	8
		Low (Upto 8th Std.)	32	32
		Medium (Matric & Inter)	41	41
		High (Graduation & above)	19	19
2.	Occupation of husband	Unemployed	41	41
		Agriculture	5	5
		Business	44	44
		Service	10	10

Table 3: Family Characteristics of Women Entrepreneurs

S. N.	Variables	Category	Frequency (n=100)	Percentage
1.	Land Holding	Landless	63	63
		Marginal (Upto 1 ha)	37	37
2.	Own and family income	Lower Income Group.	72	72
		Middle Income Group	16	16
		Higher Income Group	12	12
3.	Household			
	a) House type	Kutcha	16	16
		Pucca	72	72
		Double storied	4	8
		With marble as tiles	8	8
	b) Ownership	RentOwn	2080	2080
	c) Family type	NuclearJoint	7624	7624
	d) Family size	Small (1 to 3 members)	28	28
		Medium (4 to 6 members)	64	64
		Large (7 & above)	8	8
	e) Basic facility at home	Low (Score 1-4)	64	64
		Medium (Score 5-8)	16	16
		High (Score 9-12)	20	20

Table 4. General characteristics of enterprise runned by women entrepreneurs

S. N.	Indicator	Category	Frequency (n=100)	Percentage (%)	Mean
1.	Type of enterprise	Industry	16	16	
		Business	56	56	2.12
		Service	28	28	
2.	Years of establishing enterprise	0 to 10 years	46	46	1.6
		10 to 20 years	60	60	
3.	Size of enterprise	Small (Upto 5 employees)	96	96	
		Medium (5-10 employees)	4	4	1.04
		Large (Above 10 employees)	-	-	
4.	Net profit of enterprise	Low profit	68	68	
		Medium profit	28	28	1.36
		High profit	4	4	
5.	Age of starting enterprise	29 & under	52	52	
		30-39 years	40	40	1.56
		40-49 years	8	8	
6.	If loan has been taken for	Yes	40	40	0.4
	starting enterprise	No	60	60	
7.	If any training has been taken	Yes	64	64	0.64
	for starting enterprise	No	36	36	
8.	Registration of enterprise	Registered	8	8	0.08
		Not registered	92	92	
9.	Amount of starting enterprise	Small	40	40	
		Medium	56	56	1.64
		High	4	4	
10.	Bank account	No account	16	16	
		Own account	80	80	0.88
		In the name of SHG	4	4	

CONCLUSIONS

The findings of the study provide relevant information related with socio-economic profile of the women entrepreneurs and general information regarding their enterprise. This study confirm the needs theory of Maslow which states that the entrepreneurial motivation is determined by the social and economic needs of an individual. The main purpose of starting enterprise for majority of the respondents was to provide financial support to their families as their male partners were either unemployed or in business. They preferred to start their enterprise at the small scale with low profit which indicate low risk taking behavior. They manage their enterprise independently and take decision confidently which suggest that the women owned enterprises can be characterized as “self financed” and “self managed”.

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women entrepreneurs in different entrepreneurial activities. For economic gain they perform their work related to entrepreneurial activities. This might be the reason for the maximum involvement of landless women in entrepreneurial activities.

Own and Family Income

The income of the respondents and their family was classified in three categories as low income group, middle income group and high income group. From the Table 3 it has been revealed that majority of the respondents (72 %) belonged to the low income group followed by 16 per cent of respondents in middle income group and rest 12 per cent of the respondents were in high income group. The income of family determines the economic status and influence the opportunity of enterprise growth and expansion.

Household

It includes type of houses, ownership family type, family size and basic faculty at home. Table 3 reveales that majority of the respondents (72 %) possessed pucca house, 16 per cent kuccha house, 4 per cent double storied and rest 8 per cent having house with tiles and marble finishing. Further most of the respondents (80 %) owned their own house and rest 20 per cent have taken on rent. Majority of the respondents (76 %) enjoyed nuclear family with 4 to 6 members (64 %). Again majority of them (64 %) having low basic facility of their houses like toilet, motor lighting facility etc.

General Characteristics of Enterprise Runned by Women Entrepreneurs

This was investigated in terms of type of enterprise, year of establishing, size of enterprise, current net profit gained by enterprise, entrepreneur's age of starting enterprise, loan taken for starting enterprise, obtained training for establishing enterprise, registration of enterprise, amount of starting enterprise, ownership of enterprise, source of money for starting enterprise, management of enterprise, making decision at enterprise of money management for more investment in enterprise. The information have been compiled in Table 4.

It is evident from Table 4 that more than half of the respondents (56 %) owned business type of enterprise e.g. retail shop, boutique, embroidery and stitching center etc. Other 28 per cent of the respondents were perusing (Beauty Parlour) service type of enterprise and rest 16 per cent of the respondents owned industry type of enterprise engaged mainly in making badi, pickle, papad, fruit processing enterprises etc. Most of the respondents (60 %) were started their enterprise in last ten years. As much as 96 per cent of the enterprises were of small size having upto 5 employees. Net profit of most of the enterprises (68 %) were of low profit level whereas more than half of the respondents (56 %) were started their enterprise with the amount of medium level. Further nearly half of the respondents (52 %) were under 29 years when they start their enterprise and 64 per cent of them obtained training in their enterprise related skill. Again only 40 per cent of the women entrepreneurs take loan from Bank to start their enterprise. Majority of the enterprises (92 %) were not registered while most of the entrepreneurs (80 %) having their own bank account.

Discussion

Thus it can be summarized that majority of women entrepreneurs were low profit earner preferably owned small enterprises. it indicate that they don't want to take more risk for large enterprises but it is positive sign for Bihar state as women came forward to become partner in economic development. Although their work is invisible as 92 per cent of their enterprises were unregistered. It is also encouraging that half of them were young giving positive sign for coming generation.

Table 5 shows that in terms of ownership majority of the women entrepreneurs (80 %) had sole ownership of their enterprise and nearly half of them (48 %) takes financial help from their husbands for starting the enterprise. As much as 88 per cent of them self manage their enterprise without any help of their husbands and relatives. While most of them (76 %) make decision independently of their enterprise expanding their business 60 per cent of them manage fund from their even profit.

Ownership and managing capabilities play an important role in the involvement of women entrepreneurs in different entrepreneurial activities. Maximum number of women entrepreneurs had started their business with self money and self manage.

Table 5. Enterprise management skill of women entrepreneurs

S. N.	Indicator	Category	Frequency (n=100)	Percentage (%)	Mean
1.	Ownership of enterprise	Sole ownership	80	80	
		Partnership	4	4	2.64
		SHG	16	16	
2.	Financial management of	Self money	28	28	
	starting enterprise	Bank loan	24	24	1.80
		Help from husband/ relative	48	48	
3.	Enterprise management	Independently	88	88	2.78
		Jointly with husband	12	12	
4.	Decision making regarding	Independently	76	76	2.76
	enterprise	Jointly with husband	24	24	
5.	Financial management for	Manage from profit	60	60	
	investment in enterprise	Loan from bank	32	32	2.52
		Help from husband	8	8	

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Soil Test Crop Response (STCR) Based Nutrient Management in Sunflower Based Cropping System

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ABSTRACT

An investigation was undertaken at Oilseeds Research Unit, Dr. PDKV, Akola, Maharashtra during *Kharif-Rabi* season of 2018-19 to 2020-21 to develop a balance and integrated nutrient supply system for sunflower based cropping sequence considering the efficient utilization of residual nutrients along with added fertilizer by the crops grown in sequence. Four cropping systems with sunflower as a component crop are tested with three fertilizer levels. Four cropping systems with three levels of fertilizer 100 per cent RDF, 100 per cent STCR and 50 per cent STCR for *rabi* crops were tried in split plot design. Significantly highest system pooled sunflower equivalent yield (2829 kg ha^{-1}) was recorded in soybean–sunflower cropping system followed by sunflower – chickpea cropping system. Application of fertilizers as per 100 per cent STCR noted significantly highest system sunflower equivalent yield (2743 kg ha^{-1}) as compare to other fertilizer levels. The interaction was found non-significant. However, the interaction between cropping system and fertilizer management was significant during 2019-20 and 2020-21. Significantly highest pooled system SGMR (Rs. 159733 ha^{-1}) and SNMR (Rs. 110946 ha^{-1}) was recorded in soybean – sunflower cropping system. However, highest B:C ratio was recorded in Green gram – sunflower cropping system. The system economics was found lowest in sunflower-rabi sorghum cropping system. The highest per day return was obtained in soybean-sunflower cropping system (Rs.438 day^{-1}). Among the various method of fertilizer recommendation critical value approach, the soil test crop response (STCR), approach for target yield is unique in indicating soil test based fertilizer doses and the level of yield that can be achieved with good agronomic practices.

Sunflower, the name *"Helianthus"* is derived from '*Helios*' meaning 'sun' and '*anthus*' meaning flower. It is the important oilseed crop of the country. Sunflower oil is most popular because of its light colour, bland flavor, high smoke pint and high level of linoleic acid which is good for heart patient. Sunflower seed contains about 35 to 40 per cent oil and is naturally rich in linoleic acid (55 -70%) and consequently poor in oleic acid (20-25%). It can be grown on wide range of soil from sandy loam to black soils. It gives best result when grown under fertile well drain soil. Imbalanced fertilization and/ or inadequate replenishment of native soil nutrient reserves has resulted in the emergence of multi-nutrient deficiencies, decline in factor productivity of applied nutrients and concomitant reduction in the productivity of several crops including oilseeds in India (Hegde and Sudhakara Babu 2009). The goal of nutrient management is to maximize plant productivity while minimizing environmental consequences. Nutrient management plans document available nutrient sources, production practices and other management practices that influence nutrient availability, crop productivity and environmental consequences. The shortage and high cost fertilizers necessitate that every unit of fertilizer be used judiciously. In view of high location specific nutrient needs and soil test based fertilizer recommendation for specific crop and crop sequences. In India, sunflower is grown over the area of 2.24 lakh hectares with a production of 2.30 lakh tones and productivity of 1023 ha^{-1} during the year 2020-21 (Annon., 2022).

Farmers apply fertilizer where none is required or at lower rates than required or at higher rates as required to optimize yields. Farmers also apply inadequate rates or use ineffective application methods. Soil test based nutrient application also allows judicious and efficient use of nutrient input at the local and regional level (Sahrawat *et al*., 2010). Sharma and Singh (2005) reported existence of operational range of soil test values after fertility gradient experiment with preliminary crop pearl

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millet for development of soil test based fertilizer recommendation to obtained economic yield of wheat crop.

Among the various method of fertilizer recommendation critical value approach, the soil test crop response (STCR), approach for target yield is unique in indicating soil test based fertilizer doses and the level of yield that can be achieved with good agronomic practices. (Singh *et al.,* 2005). The current blanket fertilizer application (state or region specific) are gross approximation based on the nutrient requirement of individual crops, ignoring the carryover effect of fertilizers to the succeeding crops. Fertilizer use efficiency can be increased by adopting appropriate nutrient management strategies based on the cropping system as a whole, rather than individual crops. Hence, attempt has been made to develop an integrated nutrient supply system for the efficient utilization of residual and cumulative soil nutrient balance along with added fertilizers in the sunflower based cropping system sequence.

MATERIAL AND METHODS

A field experiment was carried out at Oilseeds Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra during *kharif-Rabi* season of 2018-19 to 2020-21. Four cropping systems with sunflower as a component crop are tested with three fertilizer levels. Four cropping systems with three levels of fertilizer 100 per cent RDF, 100 per cent STCR and 50 per centSTCR were tried in split plot design in *rabi* season. Main crop consist of four cropping system viz., C_1: Greengram- Sunflower, C_2: Soybean- Sunflower, C_3: Sunflower- Chickpea, C_4: Sunflower- Rabi Sorghum and sub plot comprises STCR based fertilization viz., F_1 100 per cent RDF, F_2 100 per cent STCR and F_3 50 per cent STCR for *rabi* season crop replicated trice and laid out in split plot design. Five plants were randomly selected by moving diagonally in the net plot, growth and yield attributes and yield were recorded at harvest. Economics was worked out on the basis of yield, cost of inputs and selling prices of crops at that time

The soil of experimental soil was medium black with clay loam type. The initial available nutrient status of the soil was low in nitrogen (182 kg ha^{-1}), medium in phosphorus (18.64 kg ha^{-1}) and high in potash (368 kg ha^{-1}). The pH 8.27, EC (dSm^{-1}) 0.34, Organic carbon (g kg^{-1}) 4.6, and Calcium carbonate per cent 6.95. The sunflower hybrid DRSH-1 was used for this experiment with a seed rate of 5 kg ha^{-1}. The green gram, soybean and sunflower were sown in *kharif* season followed by succeeding crop in *rabi* viz., sunflower, chickpea and rabi sorghum. The yield targets for sunflower, gram and *rabi* sorghum were chosen 18 q ha^{-1}, 12 q ha^{-1} and 50 q ha^{-1}.

* Fertilizer prescription equation for yield targeting in **Sunflower**

  FN = 13.94 T - 0.61 SN

  FP_2O_5 = 7.18 T – 6.82 SP

  K_2O = 4.82 T – 0.12 SK

* Fertilizer prescription equation for yield targeting in **Chickpea (Gram)**

  FN = 4.56 T - 0.18 SN

  FP_2O_5 = 12.51 T – 7.61 SP

  K_2O = 3.53 T – 0.05 SK

* Fertilizer prescription equation for yield targeting in **Rabi sorghum**

  FN = 4.7 T - 0.77 SN

  FP_2O_5 = 2.0 T – 4.29 SP

  K_2O = 3.35 T – 0.33 SK

Where F and S indicate the fertilizer and soil nutrients respectively (kg ha^{-1}) and T indicates yield target (q ha^{-1})

RESULTS AND DISCUSSION

Growth and yield attributes *of kharif* and *rabi* crops (2018-2020)

The average plant height of three years of green gram and soybean was attained as 50.12 cm and 66.38cm, respectively and sunflower attained the height was 171 cm and 168cm in two cropping system, respectively. However, average no. of pods produced in green gram and soybean were found 12.92 and 23.82 pods respectively. The average volume weight of sunflower was found as 35.19 and 34.48 $g100^{-1}$ ml in two cropping system separately. The average oil content of sunflower were found as 38.27 and 39.08 per cent, respectively. The system of soybean – sunflower responded well as compared to other cropping systems.

Likewise, when Chickpea and Sorghum were grown in *rabi* season, the significantly highest crop height was attained of sorghum (201.50cm) and Chickpea was 43.67 cm respectively followed by sunflower. The average number of pods produced by chickpea was 31.0. The average head diameter produced by sunflower was 15.0 cm and 13.8cm in different cropping system. However, significantly highest 100 seed weight recorded by Chickpea. The average oil content was recorded in sunflower was 36.67 and 35.77 per cent in different cropping system. Likewise, 100 per cent STCR treatment attained significantly highest plant height (152.13 cm) followed by 100 per cent RDF (147.74cm). The same trends was found in respect of GMR, NMR and in B:C ratio also. The lowest performance found in 50 per cent STCR. The interaction in respect of head diameter/no of pods was found significant due to varied nature of crops in cropping sequence. The 100 seed weight was not differed due to application of varied nutrients. However, volume weight responded positively and recorded significantly highest volume weight in 100 per cent STCR based fertilization. Kalaichelvi and Chinnusamy (2004) studied influence of soil test crop response base nutrients and potassium nitrate on cotton productivity. They reported that, application of 100 per cent STCR recommended NPK fertilizer combined with the soil application of potassium nitrate either 30 kg or 40 kg hg^{-1}. Application of fertilizers based on STCR along with foliar application of micronutrients significantly recorded higher head diameter, 100 seed weight, number of filled seed $head^{-1}$, seed filling per cent in sunflower. (Shanwad *et al.,*)

Sunflower equivalent yield and oil yield (PSSY)

The data regarding system equivalent yield and oil yield are presented in Table 2. The result revealed that, significantly highest pooled system sunflower equivalent yield (2829 kg ha^{-1}) was recorded in soybean-sunflower cropping system followed by in Sunflower – Chickpea cropping system (2697 kg $ha^{-1)}$. The same trend was found in respect of oil yield also and significantly highest oil yield was recorded in Sunflower-chickpea cropping system. Application of fertilizers as per 100 per cent STCR (F_2) recorded significantly highest sunflower equivalent yield (2743 kg $ha^{-1)}$ as compare to other fertilizer levels. The same trend was found in respect of oil yield. The interaction between cropping system and fertilizer in respect of sunflower equivalent yield and oil yield was found non significant. From the interaction (Table 2.1), it is revealed that, the highest system sunflower yield was obtained in sunflower – soybean crop sequence with 100 per cent STCR, however it was at par with same system with RDF and sunflower chickpea cropping system with 100 per cent STCR during 2020-21. The continuous cropping for 10 years along with STCR based fertilizer application in target yield 35 quintal per hector + 5 tones FYM ha^{-1} recorded the highest gain yield 34.9 quintal ha^{-1} (Deeksha Choudhary and Shashi Pal Dixit, 2022). Srijaya *et al*. (2017) conducted a research to validate the STCR equation developed for sunflower crop of *Cuddapah* soils of Andhra Pradesh. It was observed that, the highest yield of 22.23 quintal ha^{-1} was obtained in treatment of Targeted yield over farmers practice (13.71 quintal ha^{-1}). The increase in yield due to application of fertilizers based on different approaches was attributed to the increase in growth and yield attributes as a consequent of improved nutrient supply and efficiency of applied fertilizers in soil (Apoorva *et al.,* 2010)

Economics of system

The highest sunflower equivalent yield, net monetary return were obtained in soybean - sunflower crop sequence with 100 per cent STCR, however it was found at par with soybean –sunflower cropping system with 100 per cent RDF and Green gram –sunflower and sunflower –chickpea cropping system with 100 per cent STCR. Significantly highest GMR (Rs. 159733 ha^{-1}), NMR (Rs.110946 ha^{-1}) were recorded in soybean- sunflower cropping system. However, lowest interaction was found in sunflower-rabi sorghum cropping system. The highest B:C ratio was recorded in greengram – sunflower cropping system (3.83) followed by Sunflower-chickpea and soybean-sunflower cropping system. The highest GMR (Rs. 155182 ha^{-1}), NMR (Rs. 109133 ha^{-1}) and B:C (3.75) ratio was recorded in 100 per cent STCR followed by in 100 per cent RDF. The lowest value was found in 50 per cent STCR treatment. This result was also exhibited by Srijaya *et al*. (2017) and observed highest B:C ratio in STCR based fertilization as compared to farmers practice. In respect of economics, inteaction was found non significant. As regards to oil content, there is no any significant variation in oil contents in sunflower, however

Table 1: Growth and yield attributes of *kharif* and *rabi* crops (Pooled 2018-2020)

Treatments	Plant height (cm)		Head diameter/ No of pods plant^{-1} cob^{-1} plant^{-1}		100 Seed weight (g)		Volume weight (g/100ml)		Oil content (%)	
	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi
Main plot: Cropping System (04)										
C_1: Greengram- Sunflower	50.12	168.81	12.92	13.8	3.39	4.95	—	33.2	—	36.67
C_2: Soybean- Sunflower	66.38	172.45	23.82	15.0	8.53	5.05	—	30.0	—	35.77
C_3:Sunflower- Chickpea	171.32	43.67	13.57	32.0	4.51	19.97	35.19	25.8	38.27	—
C_4: Sunflower- Rabi Sorghum	168.90	201.50	14.09	01	4.50	3.17	34.48	63.2	39.08	—
SE(m)+		3.53		1.03		0.40		0.32		
CD at 5%		12.21		3.58		1.38		1.11		
Sub plot: Fertilizer levels (03)										
F_1- 100% RDF	—	147.74	—	15.6	—	8.23	—	37.6	—	—
F_2 -100 % STCR	—	152.13	—	17.5	—	8.65	—	39.7	—	—
F_3- 50 % STCR	—	139.96	—	13.4	—	7.98	—	36.8	—	—
SE(m)+		1.55		0.36		0.23		0.34		
CD at 5%		4.66		1.09		NS		1.02		
Interaction (CxF)										
SE(m)+		3.11		0.72		0.47		0.68		
CD at 5%		NS		2.17		NS		NS		

Table 2: Sunflower equivalent yield, and Oil yield as influenced by cropping system and fertilizer levels. (2018-2021)

Treatments	Sunflower equivalent Yield (Kg ha^{-1})				Oil yield (Kg ha^{-1})			
	2018-19	2019-20	2020-21	Pooled	2018-19	2019-20	2020-21	Pooled
A) Main plot: Cropping System (04)								
C_1: Greengram- Sunflower	2133	2877	2401	2543	835	1079	880	930
C_2: Soybean- Sunflower	2082	3324	2659	2829	907	1270	1017	1062
C_3: Sunflower- Chickpea	2525	3271	2515	2697	883	1263	962	1035
C_4: Sunflower- Rabi Sorghum	1786	1763	2349	1915	629	673	918	739
SE (m) ±	29.90	54.5	35.74	22.0	20.6	20.80	13.35	12.47
CD @ 5 %	103.47	188.5	123.67	75.0	71.4	71.99	46.19	43.1
B) Sub plot : Fertilizer (kg ha-1) (3)								
F_1- 100% RDF	2071	2818	2595	2517	791.2	1075	988	950
F_2 -100 % STCR	2226	3093	2840	2743	848.6	1180	1081	1034
F_3- 50 % STCR	2097	2515	2008	2229	800.5	959	765	841
SE (m) ±	48.4	32.5	50.7	31.4	17.97	12.4	19.2	11.9
CD @ 5 %	NS	97.3	152.12	94.3	NS	37.0	58	36.0
C) Interaction (C x F)								
SE (m) ±	96.7	64.9	101.5	63	35.94	24.73	38.37	23.75
CD @5 %	NS	194.6	304.23	NS	NS	74.16	115.03	NS

Table 2.1 Interaction of cropping systems and fertility levels on sunflower equivalent yield (kg/ha) (2020-21)

Treatments	F1- 100% RDF	F2- 100% STCR	F3- 50% STCR	Mean (Cropping System)	ANOVA	SE (m) ±	CD @ 5 %
CS-1 Green gram-sunflower	2381	2896	1927	2401	C x F	101.4	304.2
CS-2 Soybean-sunflower	2971	3027	1978	2659			
CS-3 Sunflower-chickpea	2638	2871	2034	2515			
CS-4 Sunflower-Rabi sorghum	2390	2566	2091	2349			
Mean (Fertilizer)	2595	2840	2008				

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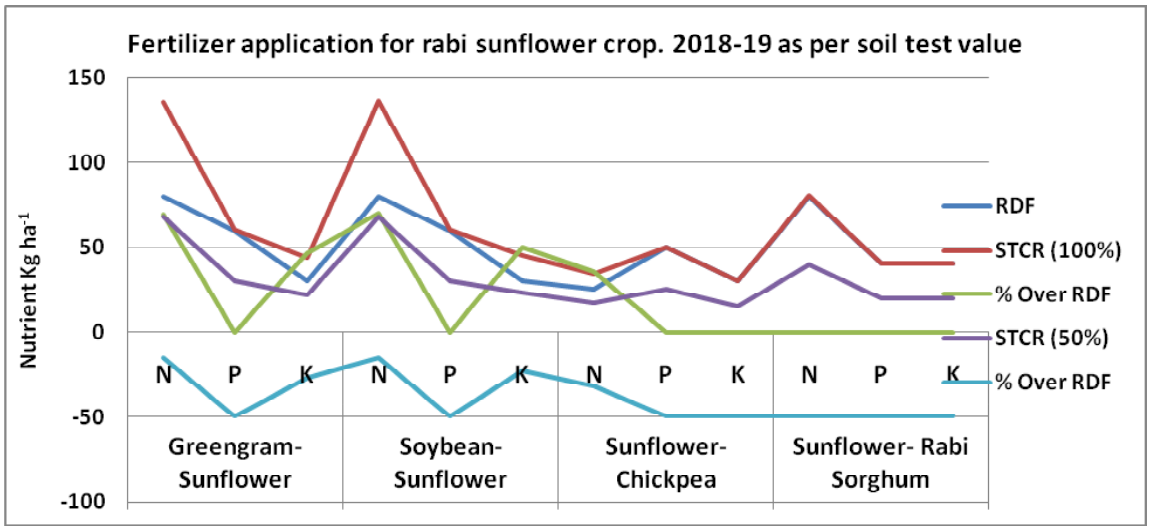
Table 3 : Economics of sunflower cropping systems as influenced by different cropping systems and fertility levels (2018 – 2020).

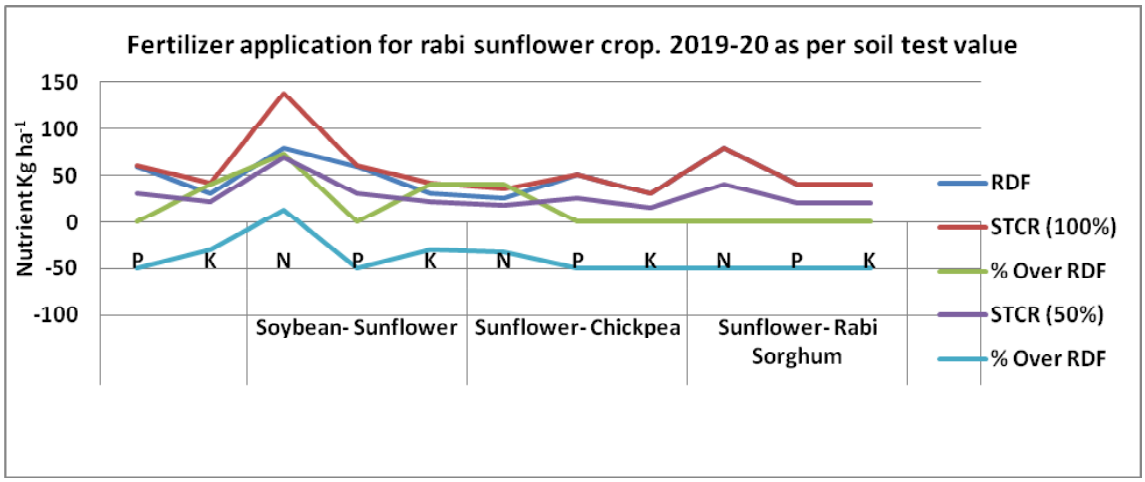
Treatments	SGMR (Rs.ha^{-1})					SNMR (Rs.ha^{-1})				
	2018 -19	2019- -20	2020 -21	Pooled	*COC* (Rs.ha^{-1})	2018 -19	2019 -20	2020 -21	Pooled	*B:C* ratio
Cropping System-4										
C_1: Greengram- Sunflower	126702	162564	141303	143523	37408	87716	128866	101762	104611	3.83
C_2: Soybean- Sunflower	134927	187806	156464	159733	44910	90321	143200	110946	114938	3.55
C_3: Sunflower- Chickpea	124223	184812	147986	152340	41547	82615	143786	105979	104099	3.67
C_4: Sunflower- Rabi Sorghum	88077	99584	138254	108638	39147	48742	60811	98919	69304	2.77
SE (m) ±	1626	3077	2103	1227	—	1626	3077	2103	1116	—
CD @ 5 %	5628	10649	7278	4247	—	5628	10649	7278	3861	—
B) Fertilizer levels -3										
F_1- 100% RDF	115209	159229	152713	142384	41490	73448	119041	110194	99348	3.42
F_2 -100 % STCR	123636	174769	167141	155182	41367	81831	134605	125010	109133	3.75
F_3- 50 % STCR	116601	142078	118151	125610	39403	76767	103852	78002	86232	3.19
SE (m) ±	2628.0	1833.5	2985.9	1769.2	—	2628.0	1833.48	2985.9	1666.0	—
CD @ 5 %	NS	5497	8952	5304	—	NS	5497	8952	4995	—
4) Intercation AxB										
SE (m) ±	5256.0	3667.0	5971.7	3538.4	—	5256.0	3667.0	5971.7	3332.0	—
CD @5 %	NS	10994	17904	NS	—	NS	10994	17904	NS	—

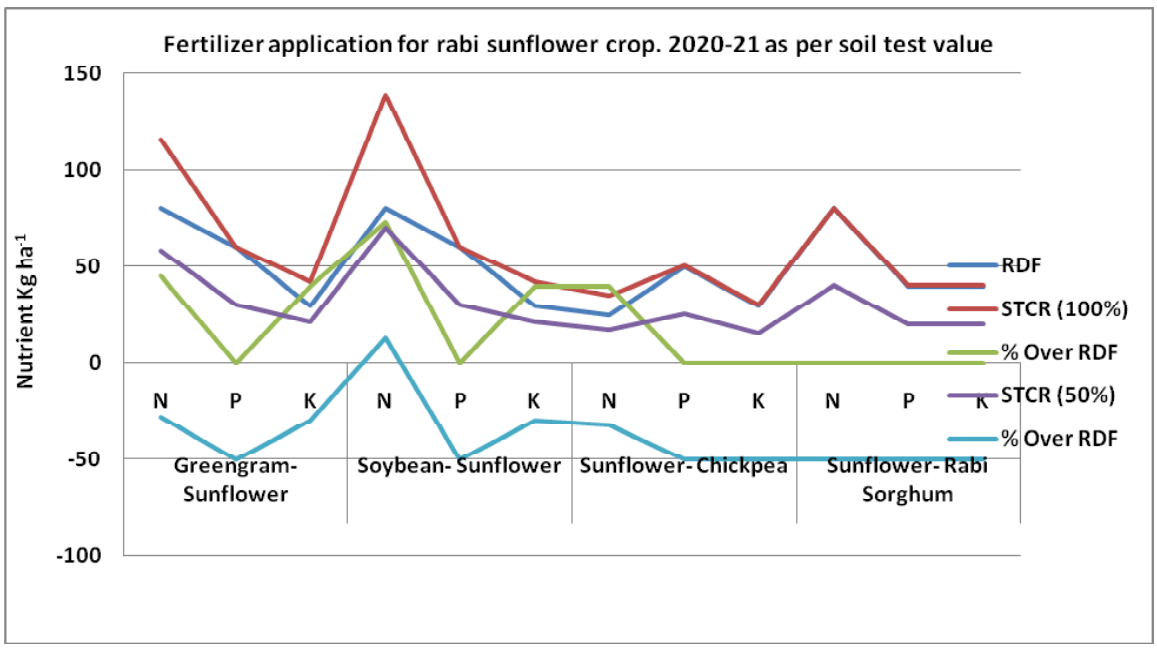
highest value of oil content was noticed in *kharif* season. The sunflower equivalent yield of groundnut – sunflower was the highest (1555 kg ha^{-1}) and found at par with setaria – sunflower (1545 kg ha^{-1}) and sunflower-sunflower (15-03 kg ha^{-1}). However, the net returns and benefit cost ratio were the highest for setaria –sunflower followed by sunflower – sunflower sequences. (Saila Sree *et al.,* 2006)

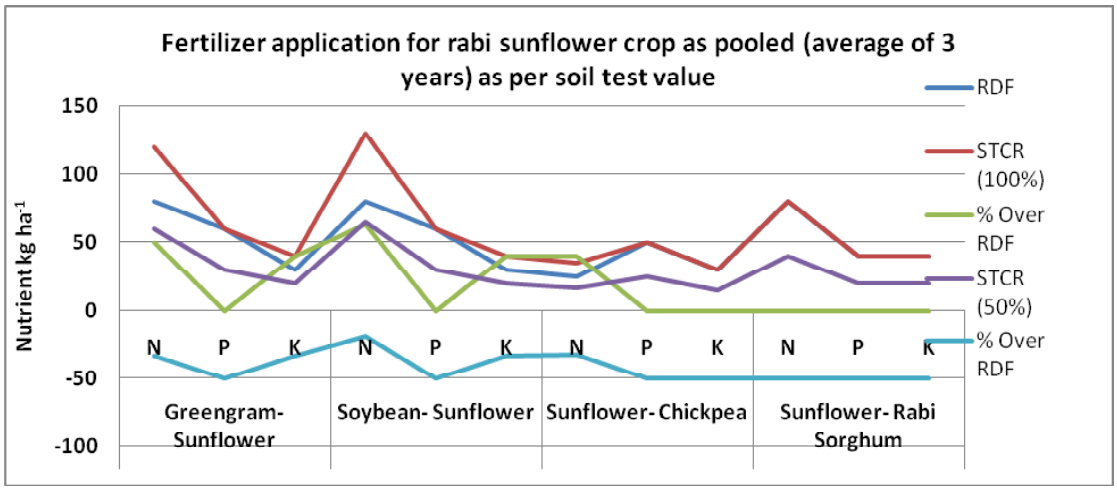
Table 4 : Per day returns as influenced by various cropping systems.

Cropping system	Per day returns (Rs.)
C_1 : Greengram- Sunflower	393
C_2 : Soybean- Sunflower	438
C_3 : Sunflower- Chickpea	417
C_4 : Sunflower- Rabi Sorghum	298


Fertilizer application for rabi sunflower crop. 2018-19 as per soil test value
Nutrient Kg ha-1
150
100
50
0
-50
-100
N P K N P K N P K N P K
Greengram-Sunflower
Soybean-Sunflower
Sunflower-Chickpea
Sunflower- Rabi Sorghum
RDF
STCR (100%)
% Over RDF
STCR (50%)
% Over RDF


Fertilizer application for rabi sunflower crop. 2019-20 as per soil test value
Nutrient Kg ha-1
150
100
50
0
-50
-100
P K N P K N P K N P K
Soybean- Sunflower
Sunflower- Chickpea
Sunflower- Rabi Sorghum
RDF
STCR (100%)
% Over RDF
STCR (50%)
% Over RDF


Fertilizer application for rabi sunflower crop. 2020-21 as per soil test value
Nutrient Kg ha-1
150
100
50
0
-50
-100
N P K N P K N P K N P K
Greengram-Sunflower
Soybean- Sunflower
Sunflower-Chickpea
Sunflower- Rabi Sorghum
RDF
STCR (100%)
% Over RDF
STCR (50%)
% Over RDF



The highest per day return was recorded in soybean – sunflower cropping system (Rs. 438 day^{-1}) followed by sunflower- chickpea cropping system. However, sunflower-chickpea cropping system gave comparatively higher returns due o assured and higher price for the chickpea crop. Hence on the basis of remunerative price the both systems are recommended for the Vidarbha region.

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Effect of Legume Green Manuring Crops on Population of Beneficial Microorganisms in Soil

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ABSTRACT

An experiment was carried out at Agronomy Farm,Divisionof Agronomy,College ofAgriculture, Pune during *kharif,* 2021 with eight treatments replicated four times inRandomized Block Design. Eight treatments were dhaincha, sannhemp, green gram, black gram, cowpea, french bean, soybean are green manuring crops and control. Microbial analysis was done at four intervals i.e.at 30 DAS, 50 per cent flowering, 45 DAI and 60 DAI. Among all treatments, sannhemp (49.25 $\times 10^9$ *cfu*g^{-1} soil) and dhaincha (64.50 $\times 10^9$ *cfu*g^{-1} soil) found higher *Rhizobium* population at 30 DAS and 50 per cent flowering respectively. Significantly higher *Rhizobium* population was found insannhemp(102.25$\times 10^9$ *cfu*g^{-1} soil) after 45 and 60 days of incorporationhowevercontrol treatment noted lower population. The *Rhizobium* population was lower at initialstage, reachingat highestduring 60daysafter incorporation. Considering all treatments, dhaincha (47.50 $\times 10^9$ *cfu*g^{-1} soil) found higher *Azotobacter* population at 30 DAS, 50 per cent flowering, 45 DAS and 60 DAS. Among all crops, dhaincha (43.25 $\times 10^9$ *cfu*g^{-1} soil) found higher phosphate solubilizing bacteria population at 30 DAS and at 50 per cent flowering also dhaincha (62.00$\times 10^9$ *cfu*g^{-1} soil) found superior among all. Considering potassium solubilizing bacteria population, green gram (36.75 $\times 10^9$ *cfu*g^{-1} soil) found higher population at 30 DAS. Significantly higher KSB population was found indhaincha (68.50 $\times 10^9$ *cfu*g^{-1} soil)at 50 per cent flowering. After 45 and 60 days of incorporation, dhaincha found superior in both recording 72.25$\times 10^9$ *cfu*g^{-1} soil and 96.25$\times 10^9$ *cfu*g^{-1} soil, respectively. Whereas control treatment noted lower population.

It is imperative to lower the indiscriminate application of chemical pesticides and fertilizers and, at the same time, increase agricultural production simultaneously, which is needed by the hour due to the increase in the global population and demand for food. The situation at hand requires an alternate option that has the potential to achieve the goal. It is known that microorganisms affect the health of plants both positively and negatively. Those having positive effects on plants are called beneficial microbes, while those having negative effects are called harmful microbes. Beneficial microbes have productive effects on thehealth of plants through a variety of direct and indirect ways, such as atmospheric nitrogen fixation, neutralization of fixed nutrients, generation of plant growth hormones, management of pathogenic microorganisms, activation of resistance, and soil structure enhancement (Gupta, 2012).

Organic farming is production system which avoids use of synthetically prepared chemical fertilizers. Hence organic farming is key to sustainable agriculture. Green manuring is the major part of organic farming. Green manuring is practice of ploughing under or incorporation of green manure crops at 50 percent flowering. Green manure crop is also called as fertility building crops and defined as crops grown for enhancement of fertility status of soil. Green manure crops are the crops that are grown for manuring. Green manuring can concentrate soil nutrients which are in available form. Incorporation and decomposition of green manure crops can easily done and releases nutrients in time for improving quality of soil (Sharma *et al.*2010).

Nitrogen (N) deficiency is a major limiting factor for high yielding crops all over the world (Salvagiotti *et al.*, 2008; Namvar *et al.*, 2011). Deficiency of nitrogen results reduced growth rate, chlorosis, and reduced yield (Caliskan *et al.*, 2008; Erman *et al.*, 2011). *Rhizobium* and *Azotobacter* can reduce the use of chemical fertilizers and decrease adverse environmental effects. Biological nitrogen fixation through microorganisms has been found very economical and advantages (Javaid, 2009).

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MATERIAL AND METHODS

A field experiment was laid out in Randomized Block Design with four replications and eight treatments *viz*., Dhaincha, sannhemp, green gram, black gram, cowpea, french bean and soybean with control in combinations in *kharif,* 2021. The initial soil of experimental plot was very low in available nitrogen (100.34 kg ha^{-1}), moderately high in available phosphorous (21.12 kg ha^{-1}) and high in available potassium (335.61 kg ha^{-1}).The gross plot size was 3.60 m× 4.00 m and net plot size was 2.70m × 3.40 m. The experimental plot was not fertilized with any dose of fertilizers. No any organic amendment or any other inoculation done to the plot. The seeds of different crops were sown with 22.5 cm line sowing on final land preparation following recommended seed rate. Soil sampling was done at rhizosphere with depth of 20 cm to 30 cm.

RESULTS AND DISCUSSION

1. *Rhizobium* population

Data presented in Table 1 on the *Rhizobium* population in the soil, as influenced by the incorporation of different legume green manuring crops in soil, explicitly revealed significant differences in the population assessed 30 days after sowing, 50 per cent flowering, 45 and 60 days after incorporation.

The population of *Rhizobium* in soil, appraised at 30 days after sowing different legume green manuring crops, explicitly revealed that the population of *Rhizobium* was significantly highest in the plots sown with sannhemp, which was to the tune of 49.25 x 10^9 *cfu*g^{-1} soil. The next best crop that enhanced the bacterium's population was dhaincha, which had a population of 45.75 x 10^9*cfu*g^{-1} soil. The lowest population of this bacterium was recorded in the plots where no crop was sown. The results unveiled that sannhemp was superior in ameliorating *Rhizobium's* population.

The *Rhizobium* population estimated at 50 per cent flowering stage of the different legume green manuring crops unveiled that the population of the bacterium in soil was significantly highest in the plots sown with dhaincha, which was 64.50 x 10^9*cfu*g^{-1} soil. This was followed by sannhemp, which had a population of 63.75 x 10^9*cfu*g^{-1} soil. However, the population of the bacterium in the later treatment did not differ significantly from that of the former. Thus, these two crops exhibited statistically similar effects in enhancing the population. Consequently, these two crops were most effective in promoting the organism's population. The lowest population of the bacterium in the soil was recorded in the plots where no crop was sown.

The population of *Rhizobium* assessed 45 days after the incorporation of the green manuring crops explicitly indicated that the population of the bacterium in soil was significantly highest in the plots incorporated with sannhemp, which was to the tune of 102.25 x 10^9*cfu*g^{-1} soil. The plots incorporated with soybean crop biomass recorded a population of 99.0 x 10^9*cfu*g^{-1} soil, which was the next in order of efficacy in increasing the population

Table: Methods used for analysis of micro-organisms from soil.

S.N.	Parameter	Method used	Media used	Reference
1.	*Rhizobium* ($\times 10^9$ *cfu* g^{-1} soil)	Serial dilution plate count	Yeast extract agar media	Colwell and Zambruski (1972)
2.	*Azotobacter* ($\times 10^9$ *cfu* g^{-1} soil)	Serial dilution plate count	Jenson media	Colwell and Zambruski (1972)
3.	Phosphorous Solubilizing Bacteria (PSB) ($\times 10^9$ *cfu* g^{-1} soil)	Serial dilution plate count	Pikovskaya's media	Colwell and Zambruski (1972)
4.	Potassium Solubilizing Bacteria (KSB) ($\times 10^9$ *cfu* g^{-1} soil)	Serial dilution plate count	Glucose + yeast + $CaCO_3$ + Distilled water	Colwell and Zambruski (1972)

of the bacterium. The lowest population to the extent of 21.50 x 10^9*cfu*g^{-1} soil was recorded in the plots, where no crop was incorporated in the soil as green manuring.

Rhizobium population in the soil, appraised at 60 days after the incorporation of the green manuring crops, explicitly indicated that the plots incorporated with sannhemp as green manuring had the highest number of the bacterium was 105.25 x 10^9*cfu* g^{-1} soil. The next best set of legume green manuring crops was soybean and dhaincha, which recorded the population to 99.75 and 99.0 x10^9*cfu*g^{-1} soil, respectively. Finally, the lowest population of 23.25 x 10^9*cfu*g^{-1} soil was recorded in the plots, where no crop was incorporated in the soil as green manuring.

Root exudates mainly include sugars, amino acids, peptides, vitamins, nucleotides, organic acids, and enzymes. Among these, organic acids play an essential role in biological reactions. *Rhizobium* bacteria populations can differ, which is significant in plants with more branches, taller, and have much vegetation. This could be because of individual genetic makeup. *Rhizobium* is primarily multiplied inside nodules, which are absorbed into or shed off of the root throughout the growth of the host plant legumes. This releases all of the *Rhizobium* into the soil. This could cause a rise in *Rhizobium* numbers in the soil following the addition of green manures. This result agrees with Hamza and Alebejo (2017) and Ali *et al*. (2018).

2. *Azotobacter* population

Data presented in table 2 on *the Azotobacter* population in the soil, as influenced by the incorporation of different legume green manuring crops in soil, explicitly revealed significant differences in the population assessed 30 days after sowing, 50 per cent flowering, 45 and 60 days after incorporation.

The population of *Azotobacter* in soil appraised 30 days after sowing different legume green manuring crops, explicitly revealing that the population of *Azotobacter* was significantly highest in the plots sown with dhaincha, which was to the tune of 47.50 x 10^9 g^{-1} soil. The next best crop that enhanced the bacterium's population was sannhemp, which had a population of 42.75 x 10^9 g^{-1} soil. The lowest population of this nitrogen-fixing bacterium was recorded in the plots where no crop was sown. The results unveiled that dhaincha was superior in ameliorating the population of *Azotobacter.*

The population of *Azotobacter* estimated at50 per cent flowering stage, 45 DAI and 60 DAI of the different legume green manuring crops unveiled that the population of the bacterium in soil was significantly highest in the plots sown with dhaincha, which was 76.75 ,94.25 and 96.25 x 10^9*cfu*g^{-1}soil respectively. This was followed by sannhemp, which had a population of64.50,89.50 and 89.25 x 10^9*cfu*g^{-1}soil. Consequently, these two crops were most

Table 1. Microbial population of *Rhizobium* in soil as influenced by different treatments

Tr. No.	Treatment	Microbial population (*Rhizobium*)(×10^9 *cfu* g^{-1} soil)			
		30 DAS	50% flowering	45 DAI	60 DAI
T_1	Dhaincha	45.75	64.50	97.50	99.00
T_2	Sannhemp	49.25	63.75	102.25	105.25
T_3	Green gram	42.75	52.75	93.75	95.25
T_4	Black gram	41.50	61.75	90.00	93.00
T_5	Cowpea	41.50	60.75	92.00	95.75
T_6	French bean	35.00	52.00	86.00	88.50
T_7	Soybean	40.25	52.00	99.00	99.75
T_8	Control	19.50	22.00	21.50	23.25
	S.E. (m) ±	0.97	0.71	0.92	0.59
	C.D. at 5%	2.87	2.11	2.74	1.75
	General mean	39.43	53.68	85.28	87.46
	Initial	20	20	20	20

effective in promoting the organism's population. On the other hand, the soil's lowest population of the bacterium was recorded in the plots where no crop was sown.

The lowest population to the extent of 24.00 x 10^9*cfu*g^{-1} soil was recorded in the plots, where no crop was incorporated in the soil as green manuring. A rise in the amount of organic matter in the soil may cause an increase in the *Azotobacter* population. The highest population of *Azotobacter* may be attributed to the fast breakdown of crops and the rapid release of decomposition products. The inclusion of green manure provided *Azotobacter* with the ideal pH for growth. Earlier researchers also have a similar opinion to Islam *et al*. (2008) that legume-grown plots recorded higher *Azotobacter* numbers.

3. PSB population

The population of PSB in the soil as affected by the inclusion of several legume green manuring crops was explicitly shown to differ significantly at 30 days after sowing, 50 per cent flowering, 45, and 60 days after incorporation, according to data reported in Table 3.

The population of PSB in soil, appraised at 30 DAS, 50 per cent flowering, 45 DAI and 60 DAI in different legume green manuring crops, explicitly revealed that the population of PSB was significantly highest in the plot same with dhaincha , which was 43.25, 62.00, 84.00 and 91.25 *cfu* g^{-1} soil respectively followed by sannhemp registered 43.00, 60.25, 80.50 and 84.50 x 10^9*cfu* g^{-1} soil respectively.

On the other hand, the lowest population was recorded in the plots where no crop was sown. The results unveiled that dhaincha was superior in ameliorating the population of *PSB*.

After decomposition, the amount of organic debris may have had an impact on the bacterial community in the soil. It implies that bacteria consume organic soil stuff. The moisture content of the soil is another crucial factor in microorganism life. Results are closely related with Djuuna *et al*. (2022).

4. KSB population

Data presented in Table 4. pertaining to population of KSBin soil, as influenced by incorporation of different legume green manuring crops in soil, explicitly revealed significant differences in the population assessed at 30 days after sowing, 50 per cent flowering, 45 and 60 days after incorporation.

KSBpopulation in the soil, appraised at 60 days after incorporation of the green manuring crops, explicitly indicated that, the plots incorporated with dhaincha as green manuring, had the highest number of the bacterium,

Table 2. Microbial population of *Azotobacter* in soil as influenced by different treatments

Tr. No.	Treatment	Microbial population (*Azotobacter*)(×10^9 *cfu* g^{-1} soil)			
		30 DAS	**50% flowering**	**45 DAI**	**60 DAI**
T_1	Dhaincha	47.50	76.75	94.25	96.25
T_2	Sannhemp	42.75	64.50	89.50	89.25
T_3	Green gram	37.25	63.50	88.25	89.75
T_4	Black gram	41.00	51.50	90.00	91.25
T_5	Cowpea	36.00	54.50	89.75	91.00
T_6	French bean	35.00	49.50	85.00	87.25
T_7	Soybean	39.25	56.00	91.75	93.75
T_8	Control	23.75	26.25	25.50	24.00
S.Em±		0.83	0.88	1.06	0.61
C.D. at 5%		2.46	2.60	3.15	1.82
General mean		37.81	55.31	81.78	82.81
Initial		25	25	25	25

Table 3. Microbial population of PSB in soil as influenced by different treatments.

Tr. No.	Treatment	Microbial population (PSB)($\times 10^9$ *cfu* g^{-1} soil)			
		30 DAS	50% flowering	45 DAI	60 DAI
T_1	Dhaincha	43.25	62.00	84.00	91.25
T_2	Sannhemp	43.00	60.25	80.50	84.50
T_3	Green gram	43.00	50.00	81.25	86.50
T_4	Black gram	41.50	52.75	65.75	68.75
T_5	Cowpea	41.50	58.75	69.75	73.50
T_6	French bean	31.00	47.75	50.50	53.50
T_7	Soybean	32.25	48.00	50.50	54.50
T_8	Control	22.50	25.00	24.50	26.00
	S.Em±	0.89	1.02	1.06	0.86
	C.D. at 5%	2.65	3.02	3.16	2.56
	General mean	37.25	50.56	63.37	67.31
	Initial	23	23	23	23

Table 4. Microbial population of KSB in soil as influenced by different treatments

Tr. No.	Treatment	Microbial population (KSB)($\times 10^9$ *cfu* g^{-1} soil)			
		30 DAS	50% flowering	45 DAI	60 DAI
T_1	Dhaincha	35.75	68.50	72.25	96.25
T_2	Sannhemp	31.00	64.50	66.75	94.00
T_3	Green gram	36.75	66.00	68.25	69.00
T_4	Black gram	32.25	63.00	64.75	63.00
T_5	Cowpea	35.75	61.50	63.75	67.75
T_6	French Bean	24.25	54.50	56.75	51.50
T_7	Soybean	33.25	60.75	63.25	50.25
T_8	Control	19.00	23.50	21.25	24.00
	S.Em±	0.91	1.83	1.96	0.91
	C.D. at 5%	2.72	5.42	5.82	2.70
	General mean	31.00	57.78	59.62	64.46
	Initial	21	21	21	21

which was 96.25 x 10^9 g^{-1} soil. Sannhemp was the next-best set of legume green manuring crops, recording a population of 94.00 x10^9 g^{-1} soil. The lowest population to an extent of 24.00 x 10^9 g^{-1} soil was recorded in the plots, where no any crop is grown. After decomposition, the amount of organic matter may have had an impact on the bacterial population in the soil. It indicates that organic stuff in the soil serves as bacteria's diet. The amount of moisture in the soil is another crucial factor in the survival of microorganisms. Ali *etal*. (2018).

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Kinetic Modelling of Vitamin C and Colour Loss of Kiwi Fruit Pulp at Pasteurization Temperature and Storage Condition

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ABSTRACT

Kiwifruit (or Chinese Gooseberry), scientifically known as *Actinidia deliciosa*, is originated from China and then cultivated in New Zealand. It is often called a 'Superfruit' as it is packed with comparatively higher amount of Vitamin C than oranges and other citrus fruits and is also rich in lots of other nutrients. It is considered to be a good source of antioxidants and fiber and has many health benefits to the human body as it helps to support the heart health, digestive health and the immunity. An experimentation was done on the kiwifruit to find out the color change and nutritional degradation (specifically of Vitamin C). The effect of pasteurization treatment on the degradation kinetics of vitamin C and color of kiwifruit pulp was evaluated at 60 ºC, 70 ºC and 80 ºC of pasteurization temperature for 10 minutes. The processed samples were stored at 25 ºC. Degradation kinetics of vitamin C in kiwi fruit pulp was studied at 25 ºC. The loss of vitamin C was dependent on time and temperature, which was carried out by the Arrhenius equation and activation energy. For regulating the magnitude of the parameters in agreement with the change in color of the model, the color change of kiwi fruit pulp was observed at 25 ºC storage temperature. The Physico-chemical properties were assessed by the kiwi fruit pulp pasteurized at various temperatures stored at 25ºC for 15 days. From the experiment, it was concluded that the rate of vitamin C loss was affected by the high temperature of pasteurization.

Kiwifruit (*Actinidia deliciosa*) is a temperate fruit which came to be known in 1950, but at present, it is cultivated in the whole world. The high level of vitamin C makes it highly nutritious fruit which is full of antioxidants and a good source of ascorbic acid. The kiwifruit is egg-shaped with the inner part green, beaded with black seed and covered with brown skin containing short and stiff hair. It contains ascorbic acid in high amount in comparison to orange, strawberry, lemon and grapefruits.

It is also found that consuming kiwifruit has been serving as a preventive measure for illness related to cardiovascular diseases and cancer. Different types of cancer such as stomach, lung and liver,are treated by kiwifruit prescriptions owing to its cytotoxic and antioxidant activities.Esti *et al*. (1998) investigated that the presence of ascorbic acid in kiwifruit depends on genotype, ripening degree, storage and the method of analysis used.Imeh and Khokhar (2002) suggested about the task of pre-and post-harvest factors according to the chemical composition of food obtained from the plant where maturity stage was noticed to be the significant factor for enhancing the quality of fruits and vegetables related to composition. Various biochemical, physiological and structural modifications occur during maturity stages where alteration investigates the final quality at the time of ripening. The storage condition is responsible for influencing the quality indices and nutritional contentof fresh fruit.Tavarini *et al.* (2008) also stated that harvest time and storage could affect the qualitative and nutritional features of kiwifruit.

The human eye perceives the colour, which is the penetration of wavelength reflecting from a surface object lying on the retina. As the light is focused on the object, it reflects, absorbs and then gets transmitted and the reflected light is responsible for regulating the colour of the object. Hence, there arevarious factors on which the colour formation of an object depends such as light and its various features namely amount of source, angle of view, size of object and its background from where the observers are noticing it.Particular instrumentation is present for the colour measurement of food colour correlating with the district evaluation where various colour scales are used to give detail information of colour in food. Food process industry faces challenges such as maintaining stability of colour at the time of processing and storage of food. The loss of nutrients concerning

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temperature is an essential task in the research field of food technology.

The heat treatment shows degradation in pigments where the storage is responsible for the change in green colour with time and temperature. Non-enzymatic browning is the most significant reason for deterioration while heating as it is deployed through the thermal process. Hence, the period of storage at the respective temperature in the absence of declineis established through kinetic modelling of kiwi fruit pulp by estimating the rate and temperature of the material. Kidmose and Hansen (1999) suggested about the interdependence of change in colour of cooked and stored broccoli and instrumental analysis respectively. Thus, the main objective for the research is to study the kinetics for ascorbic acid degradation along with kinetics of the colour change of kiwifruit pulp at pasteurisation temperature of 60°C, 70°C, 80°C and storage temperature at 25 °C.

MATERIAL AND METHODS

2.1 Materials

Since kiwifruit is imported in India, mature fruit was purchased from the local market of Nagpur and stored at 4 ± 0.5 ºC before the initial analysis. Initial total suspended solids (TSS), acidity, ascorbic acid colour and pH were evaluated of the kiwifruit. All the chemicals and reagents of analytical grade.

2.2 Preparation of Kiwi Fruit Pulp

Approximately 8 pieces of fruit were blanched for 5 to 6 min to make it soft and also for delaying enzymatic reactions leading to an undesired change in colour during the time of storage. It was then submerged in cold water for getting rid of excess heat loss of ascorbic acid and colour. Further, the pulp was made with the help of masher, and around 15 gm of it was packed in food laminates. Generally, 45 sachets were prepared for experimentation. Here, the laminates are used as it absorbs the moisture and act as a gas barrier as well.

2.3 Pasteurisation Treatments

The stability of ascorbic acid at various temperatures ranges was firmlyestablished. Here allthe sachets of kiwifruit pulp were inserted in the screw-capped test tube which was heated in a thermostatically controlled water bath set at an accuracy of ± 2 ºC at 60 ºC, 70 ºC and 80ºC for 10 min. Later on, it was stored at 25 ºC temperature in an incubator. The samples were taken for analysis to carry out a study of the effect of temperature on colour and ascorbic acid degradation for a continuous 15 days.

2.4 Ascorbic acid determination

The ascorbic acid determination was carried out through 2-6-Dicholoro-phenol Indophenol dye reagent as per the method illustrated by Ruck [14]. The standard of dye was maintained by taking one gram of ascorbic acid, revealing one ml of the dye. Approximately 20 ml of metaphosphoricacetic-acid was blended with 5 ml of sample for 2 min and later on filtered with the help of filter cloth. 50 ml of filtrate was prepared with 0.4% metaphosphoric acetic-acid solution. Ascorbic acid was titrated in 10 ml filtrate against the standard 2-6-Dichlorophenol Indophenol. The results of the experiment are shown in Table 1.

2.5 Kinetic modelling for Ascorbic acid degradation

Ascorbic acid degradation is explained through the reaction rate and the influence of temperature on the reaction rate. The two kinetic parameters wereused to describe the ascorbic acid loss such as reaction rate constant (k) and the Arrhenius activation energy (Ea) which were analysed as suggested by Boekel(1996).To attain the reaction rate constant, the first-order degradation was supposed as the following:

$$\frac{dC}{dT} = KC \qquad \ldots.(1)$$

Where C is the instantaneous concentration of ascorbic acid, t is time and k is the reaction rate constant ($time^{-1}$). On separating variable, integration of Eq.(1) is as followed:

$$C = C_0 \exp(-Kt) \qquad \ldots. (2)$$

Taking log on both sides, the linear equation is formed as given below:

$$\ln \frac{C}{C_0} = -Kt \qquad \ldots. (3)$$

A plot of "ln C/C_0" versus process time "t" is a straight line, as shown in Fig. 1 & 2 for the first-order reaction. The slope represents the rate constant with their respective correlation coefficients (R^2) listed in below table 1.

Vitamin C	60^0C Storage	70^0C Storage	80^0C Storage
Fresh Day 0	38±0.04	42±0.04	35±0.04
Day 1	25±0.01	23.84±0.01	20±0.01
Day 2	20±0.03	19.25±0.01	16.68±0.01
Day 3	16.9±0.03	15.78±0.01	13.78±0.01
Day 4	13.75±0.01	12.23±0.01	11.48±0.01
Day 5	10.59±0.01	9.5±0.01	9.64±0.01
Day 6	9.46±0.01	7.15±0.01	7.51±0.01
Day 7	8.99±0.01	6.43±0.01	6.6±0.01
Day 8	7.99±0.01	5.12±0.01	5.46±0.01
Day 9	5±0.01	4.62±0.01	4.25±0.01
Day 10	4.7±0.01	3.96±0.01	4.05±0.01
Day 11	3.72±0.01	3.69±0.01	3.75±0.01
Day 12	3.24±0.01	3.5±0.01	3.99±0.01
Day 13	3.24±0.01	3.39±0.01	3.44±0.01
Day 14	3.24±0.01	3.4±0.01	3.1±0.01
Day 15	3.2±0.01	3.2±0.01	2.25±0.05

Arrhenius activation energy equation was employed for determining the ascorbic acid degradation on influencing the temperature.

$$K = K_0 \exp(E_a/RT) \quad \text{....(4)}$$

where K_0 is frequency factor or pre-exponential constant; Ea (kJ/mol) is the activation energy of the reaction; T is the absolute temperature of the medium, and R is the universal gas constant (8.314kJ/mol.K). Taking log on both sides, the linear equation is formed which is given below:

$$\text{In } K = \text{in } K_0 - E_a / RT \quad \text{.... (5)}$$

The ascorbic acid and pre-exponential constant are referredbasedonE_a and K_0 in eq. 4 & 5, so they are an essential parameter for the reactions and the values were calculated from the plots of lnK versus 1/T.

2.6 Modeling for colour Degradation

The colour of the sample was evaluated as different parameters such as L (whiteness/darkness), a (redness/greenness) and b (yellowness/blueness). Estimated values were employed for figuring of the different parameters such as total colour change ("E), chroma, hue angle and Browning Index. The three various values *L, a* and *b* were used for explaining the placement of color inside a 3D visible colour space. The *L* value represented aslight–dark spectrum ranging from 0 (black) to 100 (white), and as the green–a red spectrum ranging from -60 (green) to +60 (red) and *b* as the blue-yellow spectrumranging from -60 (blue) to +60 (yellow) dimensions.

2.7 Titrable Acidity

Acidity in terms of citric acid was determined using titrimetric method (Ough, Amerine, & Sparks, 1969). Titratable acidity was measured by titration against 0.1 N sodium hydroxide solution and using 1% ethanol solution of phenolphthalein as an indicator.

2.8 Statistical Analysis

Each sample was analysed three times and the average of it was considered. To get the kinetic parameter of sample of kiwifruit pulp, the linear regression was employed. The kinetic rate constant was estimated where the value of correlation coefficient (R^2) was used for selecting reading for calculating the parameter of the model at respective pasteurization temperature.

RESULTS AND DISCUSSION

3.1. Change in vitamin C content in thermal processing

Table 1 represent the change in Vitamin C content in thermal processing at pasteurization for 15 days from initial concentration of ascorbic acid 42.71. It is clear from the data that ascorbic acid content decreases with an increase in pasteurization temperature. The initial ascorbic acid content of Kiwifruit was 42.71 mg/100gm during the period of storage. The ascorbic acid content of the fruit ranges between 25 to 155 mg/100gm of fresh weight of fruit. The non-homogeneity of nutrient was dependent on various factors such as cultivation, climatic conditions and the maturity. Tavarini*et.al* (2008) suggested that there was no change in the content of ascorbic acid of Kiwifruit harvested at 10º brix by the end of a long time storage period as well. Lee and Kader (2000) suggested that

ascorbic acid content is increased in ripening of apricot, peach & papaya whereas it decreases in apple & mango.

After complete 15 days of storage, the ascorbic acid content of Kiwifruit pulp was decreased to 3.2 mg/100 gm at 25 ºC temperature. This indicate that ascorbic acid content decreases on thermal processing. At 80 ºC, the loss of ascorbic acid was highest from initial day to complete storage day when compared to the loss at 70 ºC. Approximately 90 to 95% of vitamin C loss was found due to thermal processing at 25 ºC storage.

3.2 Kinetic study of vitamin C loss in Kiwifruit pulp

To evaluate the reaction rate constant a first ordered degradation of ascorbic acid was taken into account. The value of ascorbic acid on the first day of experiment was 42.7 ºC with concentration of ascorbic acid in 10 gm in Kiwifruit. The concentration of ascorbic acid was represented through first order reaction as shown in equ. (3) with help of plot ln (C/C_0) verses time 't' in Figure 1.

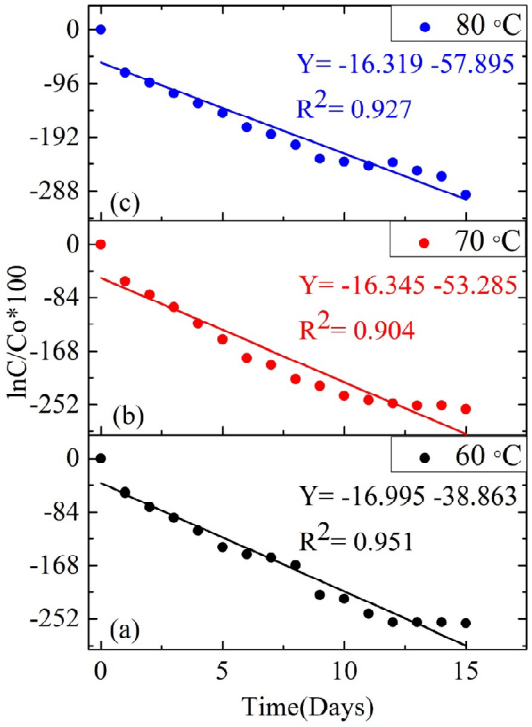

Figure 1

At all the temperature range, after the process of thermal treatment processing and subsequent storage, the Kiwifruit pulp show first order kinetics for loss of vitamin C as shown in Figure 2.

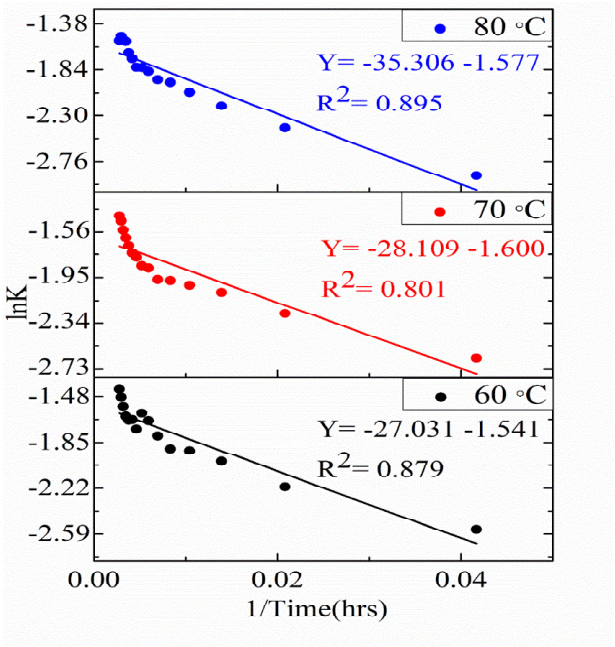

Figure 2

As the graphs presented showed high value of correlation coefficient (R^2= 0.879, R^2=0.801, R^2=0.895) at different range of temperature as the regression analysis indicate first order reaction kinetics for Kiwifruit pulp. The results are in corresponding with other studies as well, where the dependency of loss of vitamin C with respect to temperature are expressed by Arrhenius plot and activation energy (E_a) with 90 per cent confidence range as R^2= 0.895 at 80 ºC. Eqn (4) was employed for determining the ascorbic acid degradation under the influence of temperature. At varying pasteurization temperature, under the storage condition the rate constant (K) increases from -2.902 (ln K) to -1.5496 (lnK) min^{-1} at 80 ºC. The value of rate constant "K" increase from 2.6386(lnK) to -1.4221(lnK) min^{-1} at 70 □ and for 60 from -2.5536(lnK) to -1.422 (lnK) min^{-1} for ascorbic acid degradation processing temperature. The above factors indicate the thermal degradation of Vitamin C at thermal processes namely blanching, pasteurization, sterilization and storage temperature.

At the harvesting stage, titrable acidity (TA) content was decreased due to delay in harvest from standard maturity stage (6.5-7 °Brix). The lowest value of fruit harvest was noticed at 8 °Brix and TA rapidly

decreased when the storage was done. In the present study, the lower value of TA after storage was mainly accompanied by a decrease in acidity. The TA was said to be associated with a high TSS, but it was not as significant as TSS.

The TSS/TA ofkiwifruits were influenced by the harvesting stages and the interaction betweentwo variables. Dependent on harvesting stages, the storage for long-duration increase the TSS/TA of kiwi fruits. The values of TSS/T A vary in early and later stage, as in later stage the value was observed as 9 and 10 °Brix after few days of storage. The hydrolytic change instarch and conversion of starch to pure sugar lead to an increase in TSS content which was capable of ripening the fruits. The increase in the ratio of TSS/TA of fruit at storage period corresponded to the rise in TSS and decrease in TA. Glycolytic enzymes lead to starch degradation and also converted starch to sucrose as well. Hence, with an increase in the activity of glycolytic enzyme, the result obtained were the same throughout the study. But it was observed that TSS/TA was less during early harvest time in comparison to late harvest time.

3.3 Effect of pasteurisation temperature on colour kinetics of Kiwifruit at storage condition

The variation of pasteurisation temperature on colour change kinetics of Kiwifruit was pasteurizedat 60 °C, 70 °C and 80 °C temperature for 10 min, then after stored at 25 °C storage temperature. The various parameters of *L,a,b* and total colour change ("E) obtained from the experimental data and model data.

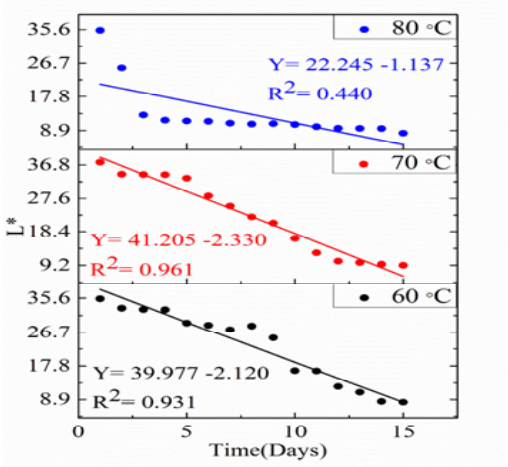

Figure 3

From the **Figure 3**, it is clear that the value of L decreases with an increase in pasteurisation temperature. It can be concluded that measurement of browning could be possible through a change in brightness of pulp[20], whichdecreases from 35.6 to 8.3 at 60 ºCtemperature,36.8 to 9.22 at 70 ºC and 35.59 to 8.89at 80 ºCrespectively.As the pulp was considering for thermal process,itisfound that reaction was non-enzymatic browning.**Figure 3** plotted state the first-order kinetics of colour degradation which is confirmed by correlation coefficient $R^2 = 0.931$ at 60 °C, $R^2 = 0.961$ for 70 °C, and $R^2 = 0.440$ for 80 °C.

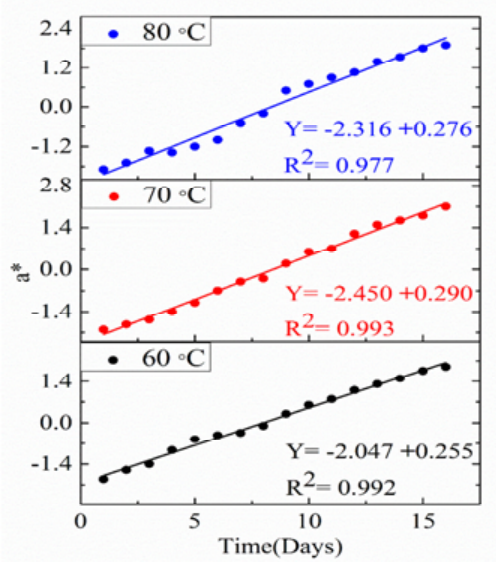

Figure 4

On the redness/greenness scale, the initial negative value reflects greenness for the value of a*. Fig.4 shows the different value of a* noted for 15 days of storage scale due to degradation of green pigment with thermal processing and storage parameters. Similarly, on yellowness/blueness scale, there is a decrease in brightness and increase in blueness with an increase in the value of b* which is mainly because of the decomposition of chlorophyll and carotenoid pigments, non-enzymatic maillard browning and also by the formation of brown pigments.

It was noticed that L* value of colour change of Kiwifruit fitted well to the first-order kinetic model. Figure 3 and Figure 4 show the kinetic parameters of *L,a,b* and total colour change ("E) and coefficients of determination.The kinetics of rate constant for L*

decreases from 35.6 to 8.3 min^{-1} , a* value from -1.85 to 2.21 min^{-1} , b value from 8.12 to 15.22 min^{-1}, and total colour change ("E) from 4.58to 0.71min^{-1} for 60 °C, Similarly L* values decreases from 36.8 to 9.22 min^{-1} , a* value from -1.85 to 2.21 min^{-1} , b value from -3.09 to 0.91 min^{-1}, and total colour change ("E) from 6.11 to 0.50 min^{-1} for 70 °C and for 80 °C,L* values decreases from 35.59 to 8.89 min^{-1} , a* value from -1.01 to 1.40 min^{-1} , b value from 6.91 to 13.84 min^{-1}, and total colour change ("E) from 12.50 to 0.40min^{-1}. This shows that with increment in pasteurisation temperature, the degradation rate of colour turns out to be quicker as an after effect pasteurisation of high vitality inside the sustenancematerial forsteady period. The outcomes acquired were in concurrence with the reviews distributed in writing and expressed by few writers that the first-order kinetics was better for L*,a*,b* value,thevalue of double concentrated tomato paste,pineapple, and peach puree.Eqn. 6 and 7 was employed to estimate the value ofchroma, Hue angle and Browning Index. It was observed that non-enzymatic browning reaction with the increase in temperature and storage time. The change in colour from green to red is due to the rise of BI value and decrease in value of lightness as shown in Figure 5. The plot of lightness versus storage period exhibit first-order kinetic for 60°Cand 70 °C pasteurisation temperature with value of R^2 as 0.736 and 0.808, but there was no particular kinetic model for non-enzymatic browning at 80 ºC.

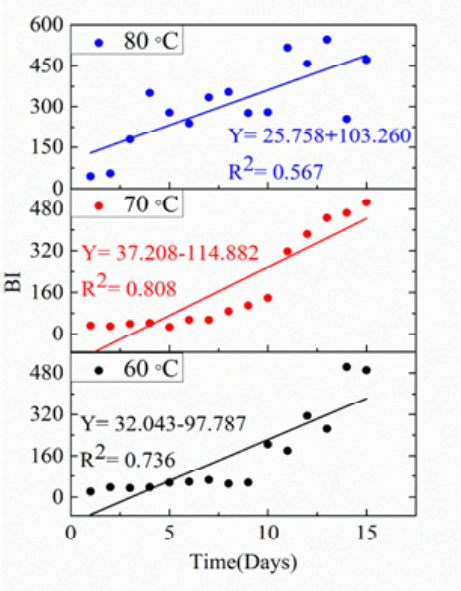

Figure 5

The value of chroma and hue angle decreases with temperature. The value of hue angle corresponds to the red, orange, yellow, green, blue or violet region. The initial hue angle of Kiwifruit was 104.19º at 60 °C representing a colour dimension of green, yellow region. On heating and storage, hue angle decreases showing a shift towards slightly reddish yellow region (83.723º, 60 °C). The process of heating shows influences on the colour profile of fruit with an increase in temperature. Hue angle at 70 °C shifted from102.94º to 88.086º and at 80 °C, it is shifted from 96.677 to 82.367º within storage period. The kinetic study states that Chroma and Hue's angle does not follow first-order kinetics.

CONCLUSION

In the current study, the effect of different pasteurisation conditions at 25ºC (room temperature) storage temperature of kiwifruit pulp, the ascorbic acid degradation and colour changesare evaluated. The loss of ascorbic acid in kiwifruit pulp at storage temperatures and pasteurisation temperature states the dependence on the first-order kinetic model. Ascorbic acid decomposes quickly at the high temperature of pasteurisation that is at 80ºC than that of 60 °Cand 70 °C. The highest ascorbic acid was noticed at 80 ºC for the Kiwifruit pulp. The parameters such as L, a, b and Chroma, hue angle for the colour change of Kiwifruit put was used to describe the real behaviour of pulp at various Pasteurization temperature i.e. 60 ºC, 70 ºC and 80 ºC. At storage temperature, the value of L, a, b, DE, Chroma, hue angle are enhanced. The BI value leads to more browning of a compound.This outcome was bolstered by the expansion in a value. The first-order kinetic models were utilised to clarify the colour change kinetics and it was observed that L, a, chroma and browning index were fitted to a first-order kinetic model. On the other hand, total colour change ("E) and hue angle values do not follow first-order kinetic model.

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Arrivals and Price Behaviourof Jowar (*Sorghum bicolour*) in Akola District

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ABSTRACT

The study is focused on behaviour of market arrivals and prices of Jowar in APMC market of Akola. Keeping in view of this study has been undertaken with objectives,to estimate the trends in arrival and prices of selected agricultural commodities and to estimate the seasonal indices of arrivals and prices of selected agriculturalcommodities. This study was based on the time series secondary data on arrival and prices of Jowar in A.P.M.C. Akola.The month wise data in respect of arrivals and prices of Jowar crop collected from the office records of APMC, Akola district was selectedpurposively for the period 2006-07 to2017-18. The simple tabular method wasused. A trend in arrivals and prices, seasonal index by using simple average method, coefficient of variability was estimated by using appropriate statistical technique. The annual compound growth rate of arrivals of Jowar (-19.55 %) was not significant during the study period. The annual compound growth rate of prices in case of Jowar (9.83 %) was highly significant at 1 per cent level.The seasonal indices of arrival showed that Jowar arrivals start rising from October and it reaches to maximum in November, there after arrival declined from February till September in APMC Akola. The prices of Jowar were highest in the month of July to March and lowest in the month of April to June in APMC Akola market. In year 2017-18 the maximum price were observed in month of July (128.55 %) followed in year 2011-12 in month of December (128.44 %). The influence of market region makes a huge impact on the market arrivals and price differs from the arrivals comes into the market.A constant market arrival makes very less change in the price if the market arrivals are more than the usual appearance price is often decrease. The more variability was observed in the arrivals of Jowar due to fluctuations in theproduction. The monthly seasonal indices of arrivals were found higher immediately after harvest. The price index of jowar was found lower during immediately after harvest. The variations in arrivals as well as prices over the years were found relatively higher.

The APMCs were established by state government for regulating the marketing of different kinds of agricultural produce. The market information relating to market prices and arrivals over a period of time helps the cereal growers to take decision about the future production pattern and sale of agricultural commodities in the market during specific period.

The price fluctuation in agricultural commodities is a common phenomenon due to their seasonal nature of production, wide ecological imbalances compared to other crops and seasonal demand for agricultural commodities. Agriculture is characterized by wide variations in output of major agricultural commodities which subsequently lead to larger variation in market arrivals. The fluctuations in market arrivals lead to the price instability of major crops. The wide fluctuations affect the farmer's capacity of making sustained efforts for increasing production. These fluctuations in prices of agricultural commodity are greatest obstacle in the way of agricultural development. Agricultural commodities arrivals and prices, therefore exercise a dominant influence on agricultural economy of our country. Fluctuations in market arrivals largely contribute to price instability and price fluctuations of agricultural commodities, there is need to have an understanding of the price behavior over time. As per price theory, prices are a function of demand and supply. But demand and supply are independently related to prices. Agriculture is being a biological industry and mostly depends on the monsoon, supplies of agricultural commodities which are uncertain and this uncertainty in supply leads to fluctuations in prices.

Sorghum (*Sorghum bicolor*) Sorghum is a major cereal crop; being grown extensively in tropical and subtropical regions of the world. It is an important food crop for a large section of people in Africa and Asia and also the main source of fodder and industrial raw material. Sorghum is also used in production of starch, biscuits, sugar and alcohol. Sorghum, the second largest grain crop in India

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till the green revolution, presently occupies third place among food grains in terms of acreage and production.

In order to reduce the price fluctuations of agricultural commodity there is need to have a thorough understanding of the price behavior over time. In recent years the seasonal variability in arrivals and prices has created serious marketing problems to farmers, consumers, planners and policy makers. The seasonality in arrival is resulted in gluts which occurred in peak season resulting in unfavorable prices to grower in peak season and high prices to consumer in off season. Thus, it is necessary and important to protect the farmer from sudden fall in prices and consumer from sharp rise in price. Abnormally, low price may be reduce the input application because of lower financial condition of farmers and will result in lower product and ultimately the lower market arrivals. Due to the fluctuations in agriculture prices, there is instability in income of the farmers, which results in instability in agricultural investment.

In order to reduce the price fluctuations of Agricultural Commodity there is a need to have through understanding of the price behavior overtime. The study of arrivals and prices helps the farmer to find out the best time for marketing of Agricultural Commodities to secure higher price for their produce.

MATERIAL AND METHODS

The present study has based on the data of arrivals and prices of Jowar in APMC Akola district for the period 2006-07 to2017-18.The study was based on the month wise data in respect of arrival and prices of selected cereals i.e. Jowar crop in APMC, Akola. Datawas analyzed statistically by simple tabular method.

The growth rate was estimated by using exponential Function

$$Ya / Yp = ab^t$$

Where,

Ya and Yp = Yearly arrivals and prices, respectively.

a =Intercept/constant

b = Trend coefficient / Regression coefficient

t = Time variable.

From the estimated function, the compound growth rate (CGR) was calculated by -

$$CGR = [Antilog (\log b)-1] \times 100$$

Seasonal index can be calculated in index form as a measure of seasonal variation. Seasonal variations in arrival and prices were calculated by simple average method.

$$\text{Seasonal index} = \frac{\text{Monthly average for that month}}{\text{Average of monthly average}} \times 100$$

RESULTS AND DISCUSTION

Trend in annual arrivals and prices of Jowar Crop:

Table1: Compound Growth rates in arrivals and prices of Jowar in APMC, Akola.

Crops	Arrivals CGR (%)	Prices CGR (%)
Jowar	-19.55	9.83***

*** indicates significance at 1 per cent level.

It can be revealed from the table 1 that, the annual compound growth rate of arrivals of Jowar -19.55 per cent was not significant during the period under study. The annual compound growth rate of prices of Jowar 9.83 per cent waspositive growth rate and was highly significant at 1 per cent level.

The Seasonal indices in arrival of Jowar in selected markets are shown in table 2.The seasonal indices of arrivals showed that Jowar arrival start rising from October and it reaches to maximum in November, there after arrival declined from February till September in APMC Akola. The maximum arrivals of Jowar observed in month of November in year 2006-07 was 601.31per cent, followed to the year 2007-08 and 2011-12 was 463.29, 315.63 per cent respectively.

The prices of Jowar were highest in the month of July to March and lowest in the month of April to June in APMC Akola market. In year 2016-17 the maximum price were observed in month of December 120.74 per cent. The

Table 2. Month wise seasonal indices arrivalsof Jowar in APMC,Akola. (per cent)

Month	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18
April	35.52	41.07	48.24	13.32	73.45	18.58	35.88	158.26	6.93	47.70	13.61	61.90
May	36.37	22.91	40.92	8.97	49.68	0.00	28.02	88.63	10.32	51.27	19.61	0.00
June	27.80	15.53	30.81	5.44	37.77	8.02	13.69	65.09	7.03	37.00	12.51	17.74
July	24.30	15.20	14.38	4.90	34.78	0.00	7.67	67.39	11.62	21.24	4.65	46.69
Aug.	32.92	19.72	19.74	9.14	45.67	8.75	24.88	36.19	13.75	28.26	14.68	32.13
Sep.	26.47	7.30	27.69	1.65	22.02	6.36	21.80	22.65	17.54	31.75	13.51	32.77
Oct.	76.46	176.52	62.61	48.59	47.67	46.49	78.04	59.63	6.02	115.47	129.33	12.96
Nov.	601.36	463.29	201.62	254.36	122.60	315.63	218.11	58.06	283.52	194.29	233.02	229.03
Dec.	163.31	217.67	67.40	150.64	118.26	120.87	137.30	50.46	190.36	39.90	98.14	81.17
Jan.	95.78	101.79	63.56	85.75	55.88	59.81	45.19	27.96	57.49	45.47	45.82	59.58
Feb.	46.76	78.09	42.31	37.20	25.05	33.01	21.80	9.17	30.43	21.99	51.95	40.59
March	32.94	40.92	30.73	30.04	17.15	32.48	17.63	6.51	14.99	15.68	13.18	35.45

Table 3. Month wise seasonal indices of prices of Jowar in APMC, Akola (per cent)

Month	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18
Apr	84.51	96.09	89.40	92.26	100.34	99.61	90.56	99.04	97.31	107.53	79.11	130.53
May	92.96	99.87	88.71	101.19	93.65	0.00	89.72	97.55	102.25	96.26	82.73	0.00
Jun	95.49	99.87	96.28	98.21	98.11	115.33	86.77	97.92	101.31	97.00	85.72	115.74
Jul	102.25	105.17	110.03	105.95	103.13	0.00	93.51	101.88	83.64	100.11	66.70	128.55
Aug	102.25	101.39	107.97	102.38	102.57	125.82	106.56	96.65	90.91	101.97	118.95	118.66
Sep	106.48	99.87	101.09	102.38	93.65	125.82	106.56	98.67	101.82	103.82	119.58	110.75
Oct	87.04	90.79	92.84	92.26	90.09	120.58	96.88	90.67	90.91	97.37	77.90	102.84
Nov	103.94	102.90	98.34	102.38	89.19	122.15	101.09	104.65	101.82	85.28	117.12	109.80
Dec	107.32	105.93	99.71	100.00	100.34	128.44	107.41	99.04	112.73	86.24	120.74	104.82
Jan	106.48	99.12	103.84	101.79	103.13	125.82	107.41	102.78	110.91	114.94	106.25	95.33
Feb	106.48	99.87	105.21	102.98	108.71	122.15	105.30	100.91	101.82	101.97	118.32	80.14
Mar	104.79	99.12	106.59	98.21	117.07	114.29	108.25	110.25	104.58	107.53	106.88	102.84

maximum price of Jowar observed in the month of July 2017-18 was 128.55 per cent followed in 2011-12 in month of December was 128.44 per cent. In year 2017-18 the maximum price were observed in month of July (128.55 per cent).

Variability in arrival and prices of Jowar Crop in APMC,Akola

Table 4. Yearly variability in arrivals of Jowar in APMC, Akola

Years	Jowar	
	Mean (qtls)	CV (%)
2006-07	12409.00	163.01
2007-08	9835.33	132.95
2008-09	9878.15	49.53
2009-10	29546.92	76.62
2010-11	12429.54	34.63
2011-12	18177.69	89.15
2012-13	14774.00	62.91
2013-14	1920.30	41.20
2014-15	3854.76	88.80
2015-16	2551.38	51.15
2016-17	3998.30	68.46
2017-18	2801.38	59.46

In case of arrivals of Jowar the variation ranged from 34.63 per cent to 163.01 per cent during the year (2006-07 to 2017-18) it was found that the average variability of arrivals of Jowar is quite high. The maximum variability in arrivals of Jowar was found during the year 2006-07 (163.01 %) and it was minimum for the year 2010-11 (34.63 %).

Table 5. Yearly variability in Prices of Jowar in APMC, Akola

Years	Jowar	
	Mean (prices)	CV (%)
2006-07	591.66	8.01
2007-08	660.83	3.97
2008-09	727.08	7.12
2009-10	840	4.17
2010-11	896.91	7.93
2011-12	953.75	47.34
2012-13	1187.08	8.06
2013-14	1337.83	4.77
2014-15	1375	8.30
2015-16	1348.5	8.50
2016-17	2070.58	20.05
2017-18	1264.08	34.39

In case of yearly price variability of Jowar the maximum price variability was found during the year 2011-12 (47.34 per cent) and it is minimum during the year 2007-08 (3.97 percent).

CONCLUSION

The annual compound growth rate of arrivals of Jowar -19.55 per cent was not significant during the period under study. The annual compound growth rate of prices of Jowar 9.83 per cent waspositive growth rate and was highly significant at 1 per cent level per annum during the study period. The seasonal indices of Jowar were revealed that the maximum arrival of Jowar was found in the month of November and minimum arrival index was noticed in the month of July. The seasonalindices of Jowar regarding prices revealed that the price index for the month of August was the highest followed by September and March. It was lowest in the month of May.

The maximum variability in arrivals of Jowar was found during the year 2006-07 and it was Minimum for the year 2010-11. In case of yearly price variability of Jowar the maximum price variability was found during the year 2011-12 and it is Minimum during the year 2007-08. The maximum variability in arrival of Jawar in market was found during the month of January and lowest in the month of April. The maximum variability was found in case of prices of Jowar in the month of May and minimum in the month of October.

The more variability was observed in the arrivals of Jowar due to fluctuations in theproduction. The monthly seasonal indices of arrivals were found higher immediately after harvest. The price index of crop was found lower during immediately after harvest. The variations in arrivals as well as prices over the years were found relatively higher.

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Heterosis and Combining Ability Studies in Safflower

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ABSTRACT

Safflower (*Carthamus tinctorius* L.) is one of the major edible oilseed crops grown in winter season in India. The first safflower hybrid released in India for commercial cultivation in all safflower growing regions was based on genetic male sterility system. Twenty two hybrids were tested using line x tester design involving two cytoplasmic male sterile lines (viz., AKS CMS 2 A and AKS CMS 3A) and eleven fertility restorer lines (viz., GMU 1654, GMU 7363, GMU 880, GMU 1894, GMU 7593, GMU 1731, GMU 7573, GMU 6891, GMU 1183, GMU 184 and GMU 5149) during rabi 2018, using Randomized block design with three replications. Twenty two along with three checks 'A-1, PBNS-12, PKV Pink' were evaluated at the field of Oilseeds Research Unit, Dr. PDKV, Akola during rabi 2019-2020 to estimate extent of heterosis in safflower genotypes. The more diverse parent, the greater are the chances of obtaining higher amount of heterotic expression in F1 and broad spectrum of variability in segregating generations. Genetic enhancement of safflower for oil yield and quality requires simultaneous improvement in seed yield, oil content and unsaturated fatty acids (oleic and linoleic acid). Therefore, knowledge on relationships among various seed yield related traits and seed traits per se are crucial to identify a suitable combination of traits and strategies for breeding cultivars with high oil yield potential in safflower. Only a few studies have explored the relationships among seed yield components and oil content in safflower. The present study was undertaken to estimate hybrid safflower breeding should provide farmers with an opportunity to improve productivity, particularly in potential high yield areas and where conventional breeding has apparently reached a yield plateau. CMS system has been found to be the most effective and practical approach for developing safflower hybrids. As hybrid technology has been perfected in safflower, current emphasis is on developing high yielding hybrids in this crop. Among twenty two hybrids, observed AKS CMS 2A x GMU 1654 (86.6 g plant^{-1}), AKS CMS 3A x GMU 1654 (82.5 g plant^{-1}), AKS 3A x 1183 (59.1 g plant^{-1}), AKS 2A x 1183 (49.5 g plant^{-1}), AKS CMS 2A x GMU 880 (29.7 g plant^{-1}) and AKS CMS 3A x GMU 1894 (28.7 g plant^{-1}) recorded highest mean seed yield than best check AKS 207 (26.7 g plant^{-1}). However genotype GMU 1183 (49.5 and 59.1 g plant^{-1}) recorded highest yield to both CMS lines. Biotechnological tools, such as genetic engineering need to be perfected for incorporation of mitochondrial male sterility causing factor of sunflower into safflower to develop safflower hybrids which can be more easily produced.

Safflower (*Carthamus tinctorius* L.) belongs to Asteraceae family commonly known as "kusum" and has 2n = 24 chromosomes. Safflower (*Carthamus tinctorius* L.) is one of the important rabi oilseed crops of India, Several reports from USAand other parts of the world have demonstrated existence of significant heterosis for yieldand total oil output in the crop. Despite numerous problems encountered currently in thelarge scale production of hybrid seeds in safflower owing to non-availability of simple,efficient and inexpensive mechanisms of cross pollination, such information obtainedfrom large number of crosses involving diverse parental types would be very useful inidentifying superior cross combinations and framing our future breeding strategies in acrop which has been found to offer great promise for semi-arid tracts in the country. This study state that the present status and future prospects of heterosis breeding of safflower in India.

It is an important oilseed crop as it contains 78 per cent of PUFA (Linoleic Acid) which is useful for heart patients as it reduces blood cholesterol levels. It also contains 16-20 per cent monosaturated fatty acid (Oleic Acid) and only 8 per cent saturated fatty acid 2-3 per cent stearic acid, 6-8 per cent palmitic acid. The often cross-pollinated nature of safflower, existence of high heterosis for seed and flower yield, presence of many traits of commercial importance and presence of genetic male sterility and cytoplasmic male sterility systems make safflower a suitable candidate for exploitation of hybrid vigor in the crop. Reports of the existence of high heterosis for seed yield and other desired traits in safflower have attracted several workers since the 1970s to seek the simple

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and easy-to-use methods of commercial-scale hybrid seed production. These hybrids in general show a 20 to 25 per cent increases in seed and oil yield over the national check A-1. In safflower, genetic as well as cytoplasmic male sterility systems are harnessed for the development of hybrid cultivars. However, the male sterility system used for the development of safflower hybrids in India is the GMS system while CMS system is in the final stages of evaluation.

MATERIAL AND METHODS

The experimental material consisted of Twenty two hybrids were tested using line x tester design involving two cytoplasmic male sterile lines (viz., AKS CMS 2 A and AKS CMS 3A) and eleven fertility restorer lines (viz., GMU 1654, GMU 7363, GMU 880, GMU 1894, GMU 7593, GMU 1731, GMU 7573, GMU 6891, GMU 1183, GMU 184 and GMU 5149) during rabi 2018, using Randomized block design with three replications. Twenty two along with three checks 'A-1, PBNS-12, PKV Pink' wereevaluated at the field of Oilseeds Research Unit, Dr. PDKV, Akola during rabi 2019-2020 to estimate extent of heterosis in safflower genotypes. All recommended cultural practices were followed to raise a good crop. The observations were recorded on five randomly selected plants for ten quantitative traits viz., days to 50 per cent flowering, days to maturity, plant height (cm), number of branches per plant, number of capitula plant^{-1}, number of seeds per capitulum, volume weight (g 100ml^{-1}), 100 seed weight (g), and seed yield plant^{-1} (g). Heterosis was calculated over mid parent, better parent and standard check for seed yield, its components and oil content.

RESULTS AND DISCUSSION

The analysis of variance for various characters under study is presented in Table 1. The variation among treatments was highly significant for all of the characters. The mean sum of square due to parents (testers), Male (testers) x Female (lines), crosses and parents vs crosses were also found highly significant for all the characters studied except number of branches per plant and number of capitula plant^{-1}. This indicates presence of substantial genetic variability for the characters studied.

The variances due to testers were highly significant for all the traits under study except 50 per cent flowering, 100 seed weight and volume weight. The variances due to crosses were highly significant for all the traits under study except number of branches per plant and number of capitula per plant which indicated the presence of significant differences between males and females.

The estimates of heterosis over mid parent (MP) and better parent (BP) for different characters in safflower are presented in Table 2. Heterosis was measured as per cent increase or decrease over mid parent (relative heterosis) and over better parent (heterobeltiosis). For calculation of relative heterosis and heterobeltiosis for days to 50 per cent flowering, plant height, number of seeds per capitulum and days to maturity, parents with less values were considered as better parent and crosses with lower values were considered as heterotic crosses. The magnitude of heterotic effects observed in different characters varied from cross to cross.Positive heterosis is desirable for all the characters studied except days to 50 per cent flowering and days to maturity where negative heterosis is desirable.Heterosis for days to 50 per cent flowering the highest, significant and negative heterosis over mid parent was observed in cross AKS CMS 3A x GMU 1183 (-6.07 %) and over and better parent was AKS CMS 2A x GMU 7593 (-10.20 %). Whereas, in case of days to maturity, the highest, significant and negative heterosis over mid parent and better parent was observed in cross AKS CMS 3A x GMU 6891and AKS CMS 3A x GMU 5149 (-5.93 % & -7.86 %, respectively).

The highest magnitude of heterosis over mid parent and better parent was for plant height at harvest was observed in cross AKS CMS 3A x GMU 1183 (32.63 and 30.16 %), respectively. In case of number of primary branches showed heterosis over mid parent and better parent was cross CMS 2A x GMU 1654 (40.35 and 37.93 %) respectively. Number of capsules per plant the cross CMS 2A x GMU 1183 (40.0 %) and CMS 3A x GMU 1655 (33.33 %) showed highest and positive heterosis over mid parent and better parent.Similar results were also reported by Narkhede *et al* (1986 and 1987) and Deokar *et al.* (1992) for both the traits in safflower. These cross combinations can be used in further breeding programme to enhance yield potential through plant height, number of primary branches and number of capsules per plant.

Table 1: Analysis of variance for combining ability

Sources of variation	DF	Seed yield (g plant^{-1})	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of branches plant^{-1}	No. of capitula plant^{-1}	No. of seeds capitulum^{-1}	100 seed wt. (g)	Volume wt. (g 100^{-1} ml)
Replicates	2	5.000	45.288 ***	7.106	680.387 ***	2.015	4.227	9.652	0.239	0.203
Crosses	21	1281.407 ***	58.188 ***	65.085 ***	127.037 ***	6.220	114.855 ***	129.666 ***	1.731 ***	17.838 ***
Females(lines)	1	0.055	30.682	0.242	8.626	2.561	4.379	5.470	0.680	12.393
Males(testers)	10	2647.880 ***	86.812	113.212 *	241.871 ***	10.179 *	223.445 ***	214.615 *	2.471	18.132
Females vs Males	10	43.069 ***	32.315 ***	23.442 ***	24.043 *	2.627	17.312	57.136 ***	1.096 ***	18.089 ***
Error	42	2.303	2.955	4.074	10.118	3.523	11.180	5.826	0.091	1.386
Total	65	415.635	22.102	23.879	68.515	4.348	44.461	45.954	0.626	6.665

Note: * Significant at 5% level of significance. ** Significant at 1% level of significance.

Table 2 : Heterosis (%) over mid-parent (MP) and better-parent (BP) for different characters

S.N.	Crosses	Seed yield(g plant-1)		Days to 50% flowering		Days to maturity		Plant height (cm)	
		MP(H_1)	BP(H_2)	MP(H_1)	BP(H_2)	MP(H_1)	BP(H_2)	MP(H_1)	BP(H_2)
1	AKS CMS 2A x GMU 1654	246.96 **	176.28 **	5.60 **	3.38	8.77 **	-1.71	10.77 *	8.81
2	AKS CMS 2A x GMU 7363	14.36 **	7.97	8.48 **	2.53	1.17	-5.12 **	13.24 **	4.12
3	AKS CMS 2A x GMU 880	18.88 **	-5.41	-3.24 *	-7.00 **	-5.67 **	-6.59 **	0.14	-5.77
4	AKS CMS 2A x GMU 1894	-10.66 *	-23.23 **	14.04 **	13.08 **	2.64 *	-0.49	16.68 **	6.44
5	AKS CMS 2A x GMU 7593	2.92	-13.28 **	-0.56	-10.20 **	-0.24	-2.56 *	6.75	6.42
6	AKS CMS 2A x GMU 1731	-17.13 **	-23.44 **	3.69 *	0.84	-1.38	-3.90 **	13.68 **	8.65
7	AKS CMS 2A x GMU 7573	18.26 **	14.67 *	6.75 **	0.75	2.55 *	2.18	5.10	1.24
8	AKS CMS 2A x GMU 6891	12.44 *	11.13	-1.02	-3.97 *	-3.30 **	-3.66 **	7.06	1.55
9	AKS CMS 2A x GMU 1183	161.85 **	157.09 **	6.43 **	1.53	5.20 **	3.66 **	28.50 **	27.60 **
10	AKS CMS 2A x GMU 184	-34.37 **	-44.05 **	4.64 **	4.64 **	2.03	-1.71	11.72 *	1.84
11	AKS CMS 2A x GMU 5149	-2.44	-13.06 *	6.14 **	2.11	2.49 *	-4.63 **	5.97	-1.48
12	AKS CMS 3A x GMU 1655	231.68 **	163.40 **	5.66 **	0.80	9.99 **	-1.67	6.77	3.67
13	AKS CMS 3A x GMU 7363	-4.07	-9.73	7.59 **	-0.80	0.90	-6.43 **	6.41	-3.21
14	AKS CMS 3A x GMU 880	-13.98 **	-31.74 **	-5.33 **	-6.61 **	-0.97	-3.10 **	4.19	-3.03
15	AKS CMS 3A x GMU 1894	29.67 **	11.10 *	-3.11 *	-6.40 **	0.62	-3.57 **	11.11 *	0.28
16	AKS CMS 3A x GMU 7593	-3.37	-18.82 **	1.47	-6.12 **	0.00	-1.16	9.40 *	8.45
17	AKS CMS 3A x GMU 1731	-5.79	-13.24 *	-2.95	-8.00 **	-4.82 **	-8.33 **	-1.41	-6.83
18	AKS CMS 3A x GMU 7573	12.91 *	9.11	4.45 **	1.12	2.28 *	1.43	3.52	-1.42
19	AKS CMS 3A x GMU 6891	20.33 **	19.35 **	-1.99	-2.38	-5.93 **	-7.38 **	8.63 *	1.89
20	AKS CMS 3A x GMU 1183	213.53 **	206.75 **	-6.07 **	-8.05 **	-1.22	-3.81 **	32.63 **	30.16 **
21	AKS CMS 3A x GMU 184	-42.07 **	-50.76 **	0.62	-2.00	-1.50	-6.19 **	3.30	-6.84
22	AKS CMS 3A x GMU 5149	-13.04 *	-22.75 **	1.49	-4.80 **	0.13	-7.86 **	6.95	-1.65
	RANGE	-42.07 to 246.96	-50.76 to 206.75	-6.07 to14.04	-10.20 to 13.08	-5.93 to 9.99	-8.33 to 3.66	-1.41 to 32.63	-6.84 to 30.16
	SE(D)±	1.0460	1.2078	1.1649	1.3451	1.3409	1.5483	2.7366	3.1600
	CD 5%	2.1108	2.4374	2.3509	2.7146	2.7061	312.47	5.5227	6.3771
	CD 1%	2.8221	3.2587	3.1430	3.6292	3.6179	4.1776	7.3836	8.5258

Note: * Significant at 5% level of significance. ** Significant at 1% level of significance.

conti…Table 2 : Heterosis (%) over mid-parent (MP) and better-parent (BP) for different characters

S.N.	Crosses	No. of branches plant^{-1}		No. of capitula plant^{-1}		No. of seeds capitulum^{-1}		100 seed wt. (g)		Volume wt. (g 100^{-1} ml)	
		MP(H_1)	BP(H_2)	MP(H_1)	BP(H_2)	MP(H_1)	BP(H_2)	MP(H_1)	BP(H_2)	MP(H_1)	BP(H_2)
1	AKS CMS 2A x GMU 1654	40.35 **	37.93 *	32.94 **	25.56 **	40.24 **	35.29 **	8.94	7.20	-0.53	-6.18 **
2	AKS CMS 2A x GMU 7363	1.69	0.00	0.00	-8.75	-5.66	-6.25	36.24 **	14.69 **	-0.41	-6.74 **
3	AKS CMS 2A x GMU 880	0.00	-3.23	-11.63	-17.39 *	9.32	7.32	15.44 **	3.97	5.70 **	-2.17
4	AKS CMS 2A x GMU 1894	-3.23	-9.09	-14.11	-15.66	-5.41	-11.39	18.37 **	16.94 **	1.18	-4.23 *
5	AKS CMS 2A x GMU 7593	-1.69	-3.33	-16.46 *	-17.50	10.98	2.13	3.64	1.59	7.50 **	0.87
6	AKS CMS 2A x GMU 1731	-11.86	-13.33	-19.48 *	-22.50 *	-38.37 **	-43.01 **	38.89 **	33.59 **	1.91	-3.35
7	AKS CMS 2A x GMU 7573	4.92	0.00	5.04	-8.75	1.30	-1.27	-6.49	-22.99 **	8.00 **	3.67 *
8	AKS CMS 2A x GMU 6891	3.45	3.45	4.90	-6.25	-14.89 *	-24.05 **	-24.67 **	-36.87 **	0.59	-5.13 **
9	AKS CMS 2A x GMU 1183	26.67 *	22.58	35.77 **	16.25	46.15 **	44.30 **	27.35 **	23.14 **	7.43 **	3.46
10	AKS CMS 2A x GMU 184	-7.14	-10.34	-35.37 **	-36.90 **	-26.51 **	-29.89 **	49.26 **	34.44 **	5.83 **	-0.92
11	AKS CMS 2A x GMU 5149	13.33	9.68	-16.46 *	-17.50	12.16	5.06	25.90 **	21.54 **	15.28 **	9.32 **
12	AKS CMS 3A x GMU 1655	20.63	8.57	38.73 **	33.33 **	14.79 *	14.12 *	24.82 **	14.77 **	-3.73 *	-5.19 **
13	AKS CMS 3A x GMU 7363	-16.92	-22.86	-19.46 *	-27.71 **	-1.22	-3.57	0.61	-7.34	7.20 **	4.78 **
14	AKS CMS 3A x GMU 880	-6.06	-11.43	-10.86	-15.22	-36.14 **	-36.90 **	-2.00	-2.65	1.70	-1.80
15	AKS CMS 3A x GMU 1894	0.00	-2.86	6.02	6.02	9.80	0.00	26.74 **	16.11 **	3.40 *	2.22
16	AKS CMS 3A x GMU 7593	-26.15 *	-31.43 *	-32.92 **	-34.94 **	-3.37	-8.51	20.00 **	10.74 *	3.98 *	1.86
17	AKS CMS 3A x GMU 1731	-7.69	-14.29	-22.29 **	-26.51 **	-6.21	-10.75	27.14 **	19.46 **	0.17	-0.78
18	AKS CMS 3A x GMU 7573	-25.37 *	-28.57 *	-16.90	-28.92 **	24.53 **	17.86 **	2.98	-7.49 *	7.85 **	7.51 **
19	AKS CMS 3A x GMU 6891	0.00	-8.57	2.74	-9.64	-8.22	-20.24 **	-20.12 **	-26.82 **	-0.31	-1.82
20	AKS CMS 3A x GMU 1183	6.06	0.00	40.00 **	18.07 *	45.34 **	39.29 **	11.45 *	-2.01	-0.89	-1.54
21	AKS CMS 3A x GMU 184	-9.68	-20.00	-32.93 **	-33.33 **	-39.18 **	-40.23 **	19.33 **	18.54 **	1.17	-1.14
22	AKS CMS 3A x GMU 5149	-15.15	-20.00	-32.92 **	-34.94 **	21.57 **	10.71	6.81	0.00	-1.01	-1.95
	RANGE	-20.0 to 40.35	-31.43 to 37.93	-35.37 to 40.0	-36.90 to 33.33	-39.18 to 46.15	-43.01 to 44.30	-24.67 to 49.26	-36.87 to 34.44	-3.73 to 15.28	-6.74 to 9.32
	SE (m) ±	1.2868	1.4859	2.0168	2.3288	1.5812	1.8258	0.1927	0.2225	0.8942	1.0325
	CD 5%	2.5969	2.9986	4.0702	4.6998	3.1911	3.6847	0.3888	0.4490	1.8046	2.0838
	CD 1%	3.4719	4.0090	5.4416	6.2834	4.2663	4.9263	0.5198	0.6002	2.4126	2.7859

Note: * Significant at 5% level of significance. ** Significant at 1% level of significance.

Among all the crosses, AKS CMS 2A x GMU 1183 (46.15 and 44.30%) exhibited highly significant and positive average heterosis for number of seeds per plant over mid and better parent. crosses, AKS CMS 2A x GMU 184 (49.26 and 34.44%) exhibited highly significant and positive average heterosis for 100 seed weight, whereas, cross AKS CMS 2A x GMU 5149 (15.28 and 9.32%) exhibited highly significant and positive average heterosis for volume weight. These results are in line of results obtained by Deedawat *et al.* (2016) in safflower.

The highest heterosis and heterobeltiosis in desirable direction were recorded for seed yield per plant in AKS CMS 2A x GMU 1654 (246.96. %) and the cross AKS CMS 3A x GMU 1183 (206.75%) showed highest and significantly positive standard heterosis over both the checks i.e. PKV PINK, AKS 207 and PBNS-12. The relative heterosis, heterobeltiosis and standard heterosis for above characters in safflower was also reported by several workers in safflower Narkhede *et al* (1986 and1987) and Deedawat *et al.* (2016)

Among twenty two hybrids, AKS CMS 2A x GMU 1654 (86.6 g plant-1), AKS CMS 3A x GMU 1654 (82.5 g plant-1), AKS 3A x 1183 (59.1 g plant-1), AKS 2A x 1183 (49.5 g plant^{-1}), AKS CMS 2A x GMU 880 (29.7 g plant^{-1}) and AKS CMS 3A x GMU 1894 (28.7 g plant^{-1}) recorded highest mean seed yield than best check AKS 207 (26.7 g plant^{-1}). However genotype GMU 1183 (49.5 and 59.1 g plant^{-1}) recorded highest yield to both CMS lines.

In Table 3 general combining ability for Seeds yield per plant the line AKS CMS 2B (0.029) showed highly significant positive GCA effects. Whereas, AKS CMS 3B (-0.2029) recorded highly significant and negative GCA effects for seeds yield per plant. The tester, GMU 1654 (54.83) and GMU-1183 (11.152) showed highly significant and positive GCA effects. The days to 50 per cent flowering among the lines, AKS CMS 3B (-0.682) revealed negative and highly significant GCA effects, whereas, another line AKS CMS 2B showed positive and highly significant GCA effects (0.682).Among the testers, GMU 1731 (-4.909) showed highest negative and significant GCA effects followed by GMU 880 (-3.242) and GMU-5149 (3.076) exhibited negative and significant GCA effects, however, GMU 7593 recorded highest, positive and highly significant GCA effect i.e. 6.924. Similar results also recorded by Patil *et al* (1992), Iqbal *et al* (2016) and Rathod *et al* (2020). Days to maturity among the lines, AKS CMS 3B (-0.661) recorded highest negative and significant GCA effects and another line AKS CMS 2B showed positive and highly significant GCA effects (-0.661).The only one tester i.e. GMU 5149 (-4.576) showed significantly negative GCA effects, whereas, GMU 7573 exhibited highest positive GCA effect (7.091).

Plant height at harvest among the lines, AKS CMS 2B (0.362) showed positively and highly significant GCA effects for plant height at harvest. Whereas, AKS CMS 3B (-0.362) showed negative and highly significant GCA effects for this trait however, GMU 1183 of tester showed significantly positive GCA effects (17.594) for plant height at harvest. Number of primary branches per plant the line AKS CMS 2B (0.197) recorded highly significant positive GCA effects for number of primary branches plant^{-1}. Whereas, AKS CMS 3B (-0.197) showed highly significant and negative GCA effects for this trait. The testerGMU 1654 (2.742) showed highly significant and positive GCA effects followed by GMU 1183 (1.909) for number of primary branches per plant.Number of capsules plant^{-1} among the lines, AKS CMS 2B (0.258) showed positive and highly significant GCA effects for number of capsules plant^{-1}, whereas, AKS CMS 3B (-0.258) recorded negative and highly significant GCA effects.The tester GMU-1654 (14.242) and GMU 1183 (7.242) showed positive and highly significant GCA effects.

Seed weight the line AKS CMS 2B (-0.102) showed negative and highly significant GCA effects for this trait whereas, AKS CMS 3B (0.102) recorded highly significant and positive GCA effects. However amongtesterGMU 184 was found with positively significant GCA effects (1.086). Number of seeds per plant the line AKS CMS 3B (0.288) showed highly significant positive GCA effects. Whereas, AKS CMS 2B (-0.288) recorded highly significant and negative GCA effects for seeds yield per plant. Amongtester, GMU-1183 (11.152) showed highly significant and positive GCA effects. Volume weight the line AKS CMS 3B (0.433) showed highly significant positive GCA effects.Similar results also

Table 3: General combining ability effects of female (line) and male (tester) for yield and yield contributing traits

	Seed yield (g plant^{-1})	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of branches plant^{-1}	No. of capitula plant^{-1}	No. of seeds capitulum^{-1}	100 seed wt. (g)	Volume wt. (g 100^{-1} ml)
Females (lines)									
AKS CMS2B	0.029	0.682 **	0.061	0.362	0.197	0.258	-0.288 ***	-0.102 ***	-0.433 ***
AKS CMS 3B	-0.029 ***	-0.682 ***	-0.061 ***	-0.362 ***	-0.197 ***	-0.258 ***	0.288	0.102 ***	0.433 **
SE (D)±	0.2575	0.2868	0.3301	0.6737	0.3168	0.4965	0.3893	0.0474	0.2201
CD (5%)	0.5197	0.5787	0.6662	1.3596	0.6393	1.0020	0.7856	0.0957	0.4443
CD (1%)	0.6947	0.7738	0.8907	1.8177	0.8547	1.3396	1.0503	0.1280	0.5940
Males (testers)									
GMU 1654	54.839 ***	-0.242 ***	1.758	1.761	2.742 *	14.242 **	7.985 **	-0.197 ***	-3.067 ***
GMU 7363	-8.994 ***	-1.242 ***	-3.909 ***	-2.284 ***	-0.758 ***	-2.424 ***	-1.348 ***	0.836 ***	0.700
GMU 880	-4.144 ***	-3.242 ***	-2.576 ***	-5.633 ***	-0.091 ***	1.076	-3.848 ***	-0.214 ***	1.617 *
GMU 1894	-5.444 ***	0.591	1.258	-0.251 ***	0.409	1.742	-1.682 ***	0.020	-0.700 ***
GMU 7593	-6.961 ***	6.924 ***	6.424 **	2.856	-1.424 ***	-4.591 ***	2.985	-0.397 ***	1.867 *
GMU 1731	-11.827 ***	-4.909 ***	-4.409 ***	-2.001 ***	-0.924 ***	-4.091 ***	-4.682 ***	0.603 ***	-1.567 ***
GMU 7573	-7.594 ***	6.758 ***	7.091 **	-2.644 ***	-0.758 ***	-2.591 ***	2.152	0.003	1.617 *
GMU 6891	-8.394 ***	-1.742 ***	-3.576 ***	-1.373 ***	0.076	0.409	-6.182 ***	-1.214 ***	-1.733 ***
GMU 1183	24.606 ***	1.091	3.924 *	17.594 *	1.909	7.242 *	11.152 ***	-0.364 ***	-1.300 ***
GMU 184	-15.861 ***	-0.909 ***	-1.409 ***	-4.356 ***	-1.258 ***	-6.424 ***	-8.515 ***	1.086 ***	0.700
GMU 5149	-10.227 ***	-3.076 ***	-4.576 ***	-3.668 ***	0.076	-4.591 ***	1.985	-0.164 ***	1.867 *
SE (D)±	0.6039	0.6726	0.7742	1.5800	0.7429	1.1644	0.9129	0.1112	0.5163
CD (5%)	1.2187	1.3573	1.5624	3.1885	1.4993	2.3499	1.8424	0.2245	1.0419
CD (1%)	1.6293	1.8146	2.088	4.2629	2.0045	3.1417	2.4631	0.3001	1.3929

Note: * Significant at 5% level of significance, ** Significant at 1% level of significance

Table 4: Specific combining ability effects of crosses

S.N.	Crosses	Seed yield (g plant^{-1})	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of branches plant^{-1}	No. of capitula plant^{-1}	No. of seeds capitulum	100 seed wt. (g)	Volume wt. (g 100^{-1} ml)
1	AKS CMS 2A x GMU 1654	1.988*	-1.848	-1.727	0.548	0.136	-1.424	3.288*	-0.515**	0.133
2	AKS CMS 2A x GMU 7363	1.821*	-1.515	-0.727	1.360	0.303	1.909	-0.712	0.752***	-3.100***
3	AKS CMS 2A x GMU 880	4.105***	-0.848	-4.061***	-2.112	-0.364	-0.591	6.121***	0.268	0.317
4	AKS CMS 2A x GMU 1894	-4.462***	4.985***	0.439	0.927	-0.864	-3.258	-2.045	-0.365*	-1.500*
5	AKS CMS 2A x GMU 7593	0.721	-2.682**	-1.061	-1.733	0.636	1.742	1.955	-0.515**	0.133
6	AKS CMS 2A x GMU 1731	-1.145	0.818	1.439	4.200	-0.864	-0.091	-4.712***	0.052	-0.333
7	AKS CMS 2A x GMU 7573	0.521	-0.848	-0.727	-0.267	0.970	2.076	-3.212*	-0.382*	-0.883
8	AKS CMS 2A x GMU 6891	-0.712	-1.348	0.939	-1.328	-0.530	-0.258	-0.879	-0.198	-0.567
9	AKS CMS 2A x GMU 1183	-4.812***	3.485***	3.439**	-2.328	0.303	-1.091	-0.212	0.152	1.500*
10	AKS CMS 2A x GMU 184	0.855	-0.182	1.439	1.855	-0.530	-0.758	1.788	0.502**	0.500
11	AKS CMS 2A x GMU 5149	1.121	-0.015	0.606	-1.123	0.803	1.742	-1.379	0.252	3.800***
12	AKS CMS 3A x GMU 1655	-1.988*	1.848	1.727	-0.548	-0.136	1.424	-3.288*	0.515**	-0.133
13	AKS CMS 3A x GMU 7363	-1.821*	1.515	0.727	-1.360	-0.303	-1.909	0.712	-0.752***	3.100***
14	AKS CMS 3A x GMU 880	-4.105***	0.848	4.061***	2.112	0.364	0.591	-6.121***	-0.268	-0.317
15	AKS CMS 3A x GMU 1894	4.462***	-4.985***	-0.439	-0.927	0.864	3.258	2.045	0.365*	1.500*
16	AKS CMS 3A x GMU 7593	-0.721	2.682**	1.061	1.733	-0.636	-1.742	-1.955	0.515**	-0.133
17	AKS CMS 3A x GMU 1731	1.145	-0.818	-1.439	-4.200	0.864	0.091	4.712***	-0.052	0.333
18	AKS CMS 3A x GMU 7573	-0.521	0.848	0.727	0.267	-0.970	-2.076	3.212*	0.382*	0.883
19	AKS CMS 3A x GMU 6891	0.712	1.348	-0.939	1.328	0.530	0.258	0.879	0.198	0.567
20	AKS CMS 3A x GMU 1183	4.812***	-3.485***	-3.439**	2.328	-0.303	1.091	0.212	-0.152	-1.500*
21	AKS CMS 3A x GMU 184	-0.855	0.182	-1.439	-1.855	0.530	0.758	-1.788	-0.502**	-0.500
22	AKS CMS 3A x GMU 5149	-1.121	0.015	-0.606	1.123	-0.803	-1.742	1.379	-0.252	-3.800***
	SE(m)±	1.2078	1.3451	1.5483	3.1600	1.4859	2.3288	1.8258	0.2225	1.0325
	CD 5%	2.4374	2.7146	3.1247	6.3771	2.9986	4.6998	3.6847	0.4490	2.0838
	CD 1%	3.2587	3.6292	4.1776	8.5258	4.0090	6.2834	4.9263	0.6002	2.7859

Note: * Significant at 5% level of significance ** *Significant at 1% level of significance*

recorded by Patil *et al.* (1992), Iqbal *et al.* (2016) and Rathod *et al.* (2020).

AKS CMS 2B (-0.433) recorded highly significant and negative GCA effects for seeds yield per plant. among tester, GMU 7593 and GMU 5149 (1.867) showed highly significant and positive GCA effects. However, GMU 1654 and GMU 1183 among the lines and AKS CMS 2A among the testers were found to be good general combiners for most of the yield contributing characters. Hence, these genotypes were recognized as the good parental material among the available genotypes for further genetic improvement programme.

In Specific combining ability effects of the 22 crosses are presented in Table 4. In safflower, positive SCA effects are desirable for all the traits studied except for days to 50 per cent flowering and days to maturity. Among crosses none of the cross showed significant SCA for plant height, number of branches per plant and number of capitula per plant. Cross AKS CMS 3A x GMU 1183 and AKS CMS 3A x GMU 1894 showed highest SCA effect for seed yield and highest negative SCA effect of days to 50 per cent flowering. Similar results also recorded by Iqbal *et al.* (2016) and Rathod *et al.* (2020). Cross AKS CMS 2A x GMU 880 showed highest negative SCA effect for days to maturity but showed positively highest SCA effect for number of seeds per capitula. Cross AKS CMS 2A x GMU 5149 showed highest SCA effect for volume weight.The present study was undertaken to estimate hybrid safflower breeding should provide farmers with an opportunity to improve productivity, particularly in potential high yield areas and where conventional breeding has apparently reached a yield plateau. CMS system has been found to be the most effective and practical approach for developing safflower hybrids. As hybrid technology has been perfected in safflower, current emphasis is on developing high yielding hybrids in this crop.

CONCLUSION

Hence, above crosses have good genetic potential due to good magnitude of useful heterosis in desirable direction for most of traits that can be utilized in further breeding programme for exploiting hybrid vigour.

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Genetic Diversity Studies in Safflower (*Carthamus tinctorius* L.)

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ABSTRACT

The investigation on Genetic diversity studies in safflower (*Carthamus tinctorius* L.)" was undertaken to estimate the extent of diversity and to estimate the contribution of each character towards genetic diversity.The set of 114 genotypes viz., 61 from IIOR Hyderabad, 22 from ORU, Dr. PDKV Akola, 18 from ZARS, Solapur and 13 from VNMKV, Parbhanialong with three checks viz., A-1, AKS-207and PKV Pink were evaluated in augmented block design with six blocks at the field of Oilseeds Research Unit, Dr. PDKV, Akola during rabi 2018-2019. The data was recorded on the characters viz., days to 50 per cent flowering, days to maturity, plant height (cm), number of branches per plant, number of capitula per plant, number of seeds per capitulum, volume weight (g 100^{-1} ml), 100 seed weight (g), oil content (%) and seed yield per plant (g). Present study revealed that the variation among the genotypes were significant for days to 50 per cent flowering, plant height, number of branches per plant, number of capitula per plant, number of seeds per capitulum, volume weight, seed yield per plant indicating the presence of wide genetic variability for these characters. While the variation among the genotypes were not significant for these characters days to maturity, 100 seed weight and oil content. It was observed that the contribution to the total divergence was the maximum by plant height (44.69%). This was followed by days to maturity (18.80%), seed yield $plant^{-1}$ (15.89%), number of seeds per capitulum (10.09%), days to 50 per cent flowering (6.84%), no. of capitula $plant^{-1}$ (2.76%), volume weight (0.78%), oil content (0.09%), no. of branches $plant^{-1}$ (0.06%). The 114 genotypes and three checks were grouped into twenty-six clusters. The average inter cluster distance was maximum between cluster XII and XI (45.93), followed by cluster XVI and XI (44.89), cluster XIII and XVI (44.08), cluster XVIII and XI (43.49), cluster XX and X (42.83). Canonical analysis indicated that overall contribution of first five canonical roots was 93.203 per cent suggesting completion of maximum portion of differentiation in the first five phases.The present study projected the importance of 9712-V-1, SSF-925-24, SSF-703 as parents for earliness while parents SSF-662, JLSF-269, AKS-205, AKS-70, IC-337833, PBNS-59, GMU-7833, SSF-703 for characters *viz.* plant height, number of branches $plant^{-1}$, number of capitula per plant, number of seeds per capitulum, 100 seed weight, volume weight, oil content and seed yield $plant^{-1}$, respectively for their further improvement in respect to yield contributing characters. On the basis of cluster means and maximum inter-cluster distance, potential crosses suggested for different traits are SPP-25 x AKS-702 for high oil and high yield potential, AKS-287 x S-473 for high yield potential with moderate volume weight and earliness, S-473 x EC-210522 for earliness with good 100 seed weight, SSF-674 x S-473 for high oil with earliness, AKS-205 x EC-210522 for high oil with high yield potential and good 100 seed weight, JLSF-269 x EC-210522 for high oil with volume weight and good 100 seed weight. Utilizing mentioned parents and crosses will be helpful for improvements of different traits and strengthening safflower breeding programme.

Safflower (*Carthamus tinctorius* L.), an oilseed crop is a member of the family Compositae. Carthamus is the latinized synonym of the Arabic word quartum, or gurtum, which refers to the colour of the dye extracted from the petals of safflower. There are 25 species in genus Carthamus out of which *Carthamus tinctorius* is only under cultivation. Safflower is being grown in over 60 countries among which India, China, Mexico, USA, Ethiopia, Argentina and Australia are the major safflower growing countries. China mostly grows safflower for medicinal purposes. Safflower acreage and production around the world has been witnessing wide fluctuations since last two decades. India has legitimate pride of being largest producer of safflower in the world. Maharashtra, Karnataka, part of Andhra Pradesh and Madhya Pradesh are the major safflower growing states in India. Maharashtra and Karnataka are most important safflower growing states accounting 73 per cent and 22 per cent area and 63 per cent and 35 per cent production, respectively. The research and development on different aspects of safflower despite its adaptability to varied growing conditions with very high yield potential and

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diversified uses of different plant parts have not received due attention.The genetic diversity is the basis of plant breeding created due to inherent genetic differences in the plant species and is of major interest to plant breeder. The more diverse parent, the greater are the chances of obtaining higher amount of heterotic expression in F1 and broad spectrum of variability in segregating generations. So, there is an urgent need of detailed genetic evaluation for variability and genetic diversity in safflower germplasm collection.

The assessment of genetic diversity in crop species is of interest for conservation of genetic resources, broadening of the genetic base and for practical applications in breeding programs. In applied plant breeding, success of the programme may be anticipated to its genetic variability of different selection method is known.

MATERIAL AND METHODS

The present investigation was carried out with the objectives to estimate genetic diversity for yield and yield attributing traits in safflower and to identify genetically diverse genotypes for yield and yield attributing traits.The set of 114 genotypes along with three checks 'A-1, AKS-207 & PKV Pink were evaluated in augmented block design with six blocks at the field of Oilseeds Research Unit, Dr. PDKV, Akola during rabi 2018-2019. The data was recorded on the characters viz., days to 50 per cent flowering, days to maturity, plant height (cm), number of branches per plant, number of capitula per plant, number of seeds per capitulum, volume weight (g 100^{-1} ml), 100 seed weight (g), oil content (%) and seed yield per plant (g).

Thus the concept of genetic distance is very important in differentiating well defined population. Several measures of distances like multivariate analysis, regression analysis, principle component analysis, ecogeographic diversity, meteroglyph analysis etc. have been proposed over past two decades to suit various objectives in which Mahalanobis generalized distance (Mahalanobis, 1930) for quantitative traits occupies prime place in plant breeding.The D2 used to measures the degree of diversificationand determines relative portion of each component trait to total divergence. According to D2 technique, if distance between the cluster or group of genotypes is more, there will be more genetically divergent parents of these groups. So these clusters will be used in hybridization programme because of genetic diversity leads to higher hetrosis. According to Rao, 1952 Genotypes clustered for high mean values of various traits could be exploited for further improvement of the crop either through selection or through hybridization.

RESULTS AND DISCUSSION

The contribution of each character towards genetic divergence has been presented in the Table no.1. The contribution to the total divergence was maximum by plant height (44.69%). This was followed by days to maturity (18.80%), seed yield $plant^{-1}$ (15.89%), number of seeds per capitulum (10.09%), days to 50 per cent flowering (6.84%), no. of capitula $plant^{-1}$ (2.76%), volume weight (0.78%), oil content (0.09%), no. of branches $plant^{-1}$ (0.06%). While 100 seed weight has not shown any contribution towards genetic divergence in the present study.

Table 1: Contribution of each character towards genetic divergence

Characters	Times rank first	% contribution
Days to 50% flowering	464	6.84
Days to maturity	1276	18.80
Plant height (cm)	3033	44.69
No. of branches $plant^{-1}$	4	0.06
No. of capitula $plant^{-1}$	187	2.76
No. of seeds $capitulum^{-1}$	685	10.09
Volume weight (g)	53	0.78
Oil content (%)	6	0.09
Seed yield $plant^{-1}$ (g)	1078	15.89

Grouping of genotypes into different clusters was done by Tocher's method and was presented in the Table 2. The 114 genotypes and 3 checks were grouped into twenty-six clusters. Cluster II was the largest involving 28 genotypes. The next largest cluster was cluster III with 21 genotypes followed by cluster IV involving 20

Table 2: Grouping of genotypes into different clusters

Cluster	No. of Genotypes	Name of Genotypes
I	14	AKS-207, PKV-PINK, A1, GMU-7492, JSI-106A, GMU-498, EC-398118, SSF-670, GMU-3965, SSF-698, IC-337805, PBNS-88, SSF-704, IC-337739
II	28	SPP-12, EC-398061, EC-210551, SSF-661, GMU-7549, IC-406052, PBNS-85, SSF-718, PBNS-72, IC-338302, PBNS-86, GMU-7901, JSI-106A, GMU-871, AKS-68, SSF-687, PBNS-84, GMU-3924, SSF-204, PBNS-66, EC-181171, GMU-7833, EC-303233, AKS-152, EC-181558, SPP-9920, JSI-7, PBNS-78
III	21	JLA-1341,9913-1-1, SSF-662, GMU-7920, PBNS-92, EC-739480, EC-337543, EC-181260, GMU-3420, IC-338171, EC-478404, GMU-7915, EC-661173, EC-337251, IC-499901, AKS-297, EC-755663, IC-499965, EC-398899, HUS-305, IC-406145
IV	20	IC-337833, EC-398239, AKS-215, AKS-33, AKS-198, AKS-298, PBNS-52, IC-337832, IC-406029, EC-283052, PBNS-59, PBNS-57, GMU-7854, EC-661163, AKS-96, AKS-288, AKS-301, PBNS-54, AKS-73, IC-338352
V	1	SSF-713
VI	1	SSF-710
VII	1	SSF-702
VIII	1	SPP-25
IX	1	PBNS-91
X	13	SPP-10, SPP-11, SSF-720, JLA-1409, SSF-658, EC-181909, SSF-9999, GMU-7866, JLSF-113, JSI-73, CVT-92108, SSF-703, EC-398376
XI	1	EC-210522
XII	1	JLSF-269
XIII	1	SSF-674
XIV	1	AKS-287
XV	1	AKS-170
XVI	1	S-473
XVII	1	SSF-9998
XVIII	1	AKS-205
XIX	1	IC-337678
XX	1	AKS-217
XI	1	AKS-113
XII	1	JSI-97
XIII	1	CVT-246
XIV	1	SSF-925-24
XV	1	9712-V-1
XVI	1	AKS-70

Table 3: Cluster means for seed yield and its attributing characters

	Days to 50% flowering	Days to maturity	Plant height(cm)	No. of branches plant^{-1}	No. of capitula plant^{-1}	No. of seeds capitulum^{-1}	100 seed wt.(g)	Volume wt. (gm 100^{-1} ml)	Oil content (%)	Seed yield plant^{-1} (g)
Cluster I	72.60	127.87	68.75	10.15	27.43	24.60	4.17	45.33	26.82	36.72
Cluster II	76.83	128.33	49.20	7.72	19.60	25.26	4.22	46.28	27.55	29.34
Cluster III	79.21	130.92	68.67	7.27	20.01	25.82	3.99	44.41	27.97	26.36
Cluster IV	81.12	140.42	48.76	8.05	21.20	27.20	4.17	48.42	28.34	30.67
Cluster V	70.56	124.22	59.10	8.47	19.50	23.50	3.92	47.24	25.84	35.59
Cluster VI	73.56	128.22	54.90	5.47	12.50	20.50	4.02	48.44	25.74	19.59
Cluster VII	70.89	126.56	57.97	7.55	22.17	35.50	3.82	44.38	27.44	27.77
Cluster VIII	77.56	127.22	54.90	4.14	15.50	18.50	3.62	43.04	25.34	17.28
Cluster IX	84.89	123.56	60.47	6.95	18.17	34.50	3.72	44.08	29.44	24.69
Cluster X	74.30	124.22	45.88	11.14	24.83	24.17	3.97	45.59	26.22	40.36
Cluster XI	80.89	123.56	42.93	5.08	11.50	33.50	4.02	45.58	25.17	20.64
Cluster XII	72.89	125.56	72.43	16.77	29.50	18.50	4.32	50.58	27.57	41.97
Cluster XIII	73.89	124.56	39.97	6.95	18.17	36.50	3.32	43.08	28.34	26.95
Cluster XIV	79.22	143.22	48.40	11.15	25.83	15.50	4.08	49.31	28.47	42.30
Cluster XV	79.22	143.22	59.50	11.15	26.83	18.50	4.08	51.01	29.17	39.82
Cluster XVI	77.89	115.56	78.33	11.72	26.50	26.50	4.02	44.78	24.97	39.88
Cluster XVII	78.56	126.22	49.80	5.81	20.50	33.50	5.02	52.14	26.04	20.51
Cluster XVIII	83.22	143.22	60.80	18.15	30.83	23.50	3.88	47.01	29.57	43.31
Cluster XIX	81.56	138.56	68.57	9.13	18.50	15.83	3.62	42.54	24.84	34.25
Cluster XX	86.22	143.22	71.40	7.15	13.83	29.50	4.28	42.31	28.87	22.81
Cluster XXI	87.22	125.22	67.70	9.15	26.83	16.50	3.28	44.11	27.97	32.80
Cluster XXII	77.56	126.22	72.30	9.14	27.50	36.50	3.82	47.64	20.34	34.55
Cluster XXIII	77.89	116.56	68.23	9.57	20.50	22.50	3.72	45.78	27.97	38.79
Cluster XXIV	78.89	112.56	52.77	6.95	19.17	27.50	4.22	46.38	27.94	25.00
Cluster XXV	77.89	111.56	60.83	10.98	24.50	34.50	3.32	42.48	25.67	38.76
Cluster XXVI	78.89	133.89	46.53	12.35	29.50	39.17	3.35	41.24	30.44	47.21

Table 4: Maximum intercluster distance and Cross combination suggested

S. N.	Cluster combination	Average intercluster distance	Cross combination suggested	Characters to be improved
1	XII x XI	45.93	JLSF-269 x EC-210522	High oil with moderate volume weight and high 100 seed weight
2	XVI x XI	44.89	S-473 x EC-210522	Earliness with high 100 seed weight
3	XIII x XVI	44.08	SSF-674 x S-473	High oil with earliness
4	XVIII x XI	43.49	AKS-205 x EC-210522	High oil withhigh yield potential and high100 seed weight
5	XX x X	42.83	AKS-217 x SSF-703	High plant height and high yield potential
6	XIV x XVI	42.70	AKS-287 x S-473	high yield potential with moderate volume weight and earliness
7	IV x XVI	42.68	PBNS-59 x S-473	High volume weightwith earliness
8	VIII x XXVI	41.61	SPP-25 x AKS-70	High oil andhigh yield potential
9	XX x XXVI	41.53	AKS-217 x AKS-70	High100 seed weightwith high yield potential
10	VI x XXVI	40.65	SSF-710 x AKS-70	High volume weight with high yield potential

genotypes followed by cluster I involving 14 genotypes followed by cluster X involving 13 genotypes.Cluster V, VI, VII, VIII, IX, XI, XII, XIII, XIV, XV, XVI, XVII, XVIII, XIX, XX, XXI, XXII, XXIII, XXIV, XXV, XXVI involves only one genotype in each cluster.

Average intra and inter cluster statistical distance among 10 characters was calculated by Tocher's method. The average inter cluster distance was maximum between cluster XII and XI (45.93), followed by cluster XVI and XI (44.89), cluster XIII and XVI(44.08), cluster XVIII and XI (43.49), cluster XX and X (42.83). Patil *et al.*(1991) observed that the size and number of capitula per plant, seed number per capitulum, 100 seed weight, yield per plant and oil content exerted marked influence on genetic diversity in safflower. Patil *et al.* (1984) and Reddy *et al.*(1993) also reported importance of these characters for genetic divergence.

The cluster means of all the 10 characters had presented in the table 3. For days to 50 per cent flowering, least cluster mean was recorded by cluster V (70.56) followed by cluster VII (70.89) and cluster I (72.60). For days to maturity cluster XXV (111.56) and cluster XXIV (112.56) showed least cluster mean. For plant height cluster XVI (78.33) and cluster XII (72.43) showed highest cluster mean. For number of branches per plant highest cluster mean was recorded as cluster XVIII (18.15) followed by cluster XXVI (12.35). For number of capitula per plant highest cluster mean was recorded as cluster XVIII (30.83) followed by cluster XII and XXVI (29.50). Cluster XXVI (39.17) showed the highest cluster mean for number of seeds per capitulum. In case of 100 seed weight, the highest cluster mean was observed in cluster XVII (5.02) followed by cluster XII (4.32) while least cluster mean was for cluster XXI (3.28). For volume weight the highest cluster mean was for cluster XVII (52.14) followed by cluster XV (51.01) For oil content, it was highest for cluster XXVI (30.44) followed by cluster XVIII (29.57) and least with cluster XXII (20.34). For seed yield per plant (g) highest cluster mean as cluster XXVI (47.21) followed by cluster XVIII (43.31).Efficient utilization of genetic potential hidden in elite genotypes requires detailed knowledge about the material under study. Such knowledge can provide major reservoir of genetic diversity useful for genetic improvement of a crop (Bhatt, 1970).

According to Allard (1960) it is usually helpful in planning pedigree programmed to regard the variety to be produced as a replacement for some well-established variety. The new variety usually cannot be much poorer in yield, adaptation or dependability than the variety it is intended to replace, irrespective of improvement of specific features. For this reason the parent is selected for their known performance in the area of intended use.

In the present study all possible combinations from twenty-six different clusters had been arranged in descending order of magnitude of genetic distance and promising cross combination were presented in the Table 4. Also in choosing the genotypes from cluster with other practical considerations like disease resistance, quality and insect resistance etc. should be taken into account. The present study projected the importance of genotypes 9712-V-1, SSF-925-24, SSF-703 for earliness as they have least mean for days to maturity whereas high mean of SSF-662, JLSF-269, AKS-205, AKS-70, IC-337833, PBNS-59, GMU-7833, SSF-703 for characters viz., plant height, number of branches per plant, number of capitula per plant, number of seeds per capitulum, 100 seed weight, volume weight, oil content and seed yield per plant respectively.

On the basis of cluster means and maximum inter-cluster distance, potential crosses suggested for different traits are SPP-25 x AKS-207 for high oil and high yield potential, AKS-287 x S-4733 for high yield potential with moderate volume weight and earliness, S-473 x EC-210522 for earliness with good 100 seed weight, SSF-674 x S-473 for high oil with earliness, AKS-205 x EC-210522 for high oil with high yield potential and good100 seed weight, JLSF-269 x EC-210522 for high oil with volume weight and good 100 seed weight .

The assessment of genetic diversity can be made on the basis of biochemical, morphological and molecular markers. Morphological markers alone do not provide sufficient information to understand genetic diversity within species because of environmental variation.

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Management of Cercospora Leaf Spot in Mungbeam

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ABSTRACT

Green gram (*Vigna radiata* L.), is one of the important pulse crops in India. There are many constraints responsible for the lower yield of mungbean where, diseases are considered dominant constraints. An experiment was conducted to evaluate the efficacy of selected fungicide against Cercospora leaf spot. Minimum intensity of disease was recorded in the treatment of Metiram + Pyraclostrobin WG (0.3%) which was 2.97 per cent, this was found significantly superior over all other treatment. The disease intensity as recorded in control was 33.27 per cent in first year. Minimum disease intensity (5.60%)was recorded in the combi product of Metiram + Pyraclostrobin WG (@0.3%) which was followed by Propiconazole (0.1%) (8.45%) in 2nd year. During 2nd yearthe disease intensity as recorded in control was 32.35 per cent. In respect of yield, 1st year, 2nd year and 3rd year yield was obtained highest *i.e.*1173.30 Kg ha^{-1},1211.50 Kg ha^{-1} and1196.56 Kg ha^{-1} in the treatment T_6 (Metiram + Pyraclostrobin WG, 0.3%) whereas, minimum yield recorded in control was 843Kg ha^{-1}, 838.70Kg ha^{-1} and 829.58 kg ha^{-1}, respectively.

Mungbean (*Vigna radiata* L.) is one the major pulse crop grown all over the world. Cercosporaleaf spot disease is an important disease of mungbean. Presently, the per capita share of pulses in nutrition supply in India with respect to energy, protein and fat is 117.4 K cal, 6.9 gm and 1.0 gm per day, respectively. An adult male and female requires 80 and 70 gm per capita per day, respectively for balanced diet. Green gram crop covers a total world area of 5 m ha with a total production of 3 m ton (John, 1991). India is contributing 23 per cent global pulses in world production from an area of about 12.08 per cent. A wide range of yield losses (23–96%) due to Cercospora leaf spot was reported in India. (Chand *et al*., 2012; Bhat *et al*., 2014). It is a widespread disease caused by the fungus *Cercospora canescens*. This disease can cause heavy defoliation in severe conditions on mungbean especially at optimum temperature 25-30 °C with RH 90-100 per cent. During favorable condition the spots increase in size and at the time of flowering and pod formation lead to defoliation in case of severe attack of Cercosporapremature defoliation is also observed. The disease can be managed by using Tebuconazole, Propiconazole, Mancozeb and Metiram + Pyraclostrobin fungicides.Major diseases include Cercospora leaf spot, powdery mildew, anthracnose, Fusarium wilt, Rhizoctonia root rot and web blight, Macrophomina charcoal rot/dry root rot and blight.Fungal pathogens can infect mungbean plants at different stages, such as during emergence, seedling, vegetative and reproductive stages and cause substantial damage leading to yield loss or complete failure of production. Species of the genera Fusarium (wilt), Rhizoctonia (wet root rot), and Macrophomina (dry root rot) infect mungbean plants during seed/seedlings stages (seed-borne or soil borne), while species of the genera Colletotrichum (anthracnose), Alternaria and Cercospora (leaf spot), Erysiphe/Podospheara (Sphaerotheca) (powdery mildew) affect plants during vegetative and reproductive stages (Ryley *et al*., 2010). Maturity delayed in the diseased plants, resulting poor pod formation. Seeds that developed on severely infected plants are small and immature (Poehlman, 1991).

There is a need for better understanding of the pathogen, the disease caused by them and so that suitable control measure can be developed. Thus, present investigation was undertaken to find out best chemical for management of Cercospora leaf spot of Mungbean.

MATERIAL AND METHODS

A field experiment was conducted at Pulses Research Unit, Dr. PDKV, Akola during Rabi 2017-2018, 2018-2019 and 2019-2020 to evaluate the bio-efficacy of fungicides against Cercosporaleaf spot of Mungbean. The trial was laid in Randomized Block Design with seven treatments and three replications for duration of three

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years. Mungbean crop variety PDKV Green gold was sown in last week of June 2018 with a spacing of 30 cm and 10 cm between rows and plants.Chemical fungicides were tested in the field, both alone and in combination, at respective concentrations. The observation on leaf spot infection were recorded at 40 DAS and continue up to harvesting at 15 days interval by selecting two leaves each from top, middle and lower portion of the plant. Seed yield was recorded from each plot, converted to kg/ha. The data obtained from all the experiments were statistically analyzed following the standard methods (Gomez and Gomez, 1984). Seven treatments viz., T1 (Carbendazim 50 WP 0.1%), T2 (Tebuconazole 25 EC 0.1%), T3 (Propiconazole 25 EC 0.1%), T4 (Hexaconazole 5 EC 0.1%), T5 (Mancozeb 75 WP (0.2%), T6 (Metiram 55 %+ Pyraclostrobin 5 per cent WG (0.3%) and T7 (untreated check) were applied with foliar spray during experiment. Cercopsora leaf spot was graded on the basis of disease intensity observed on leaves by applying 0-9 disease rating scale developed by Mayee and Datar (1986) as described below. The disease severity of Cercopsora leaf spot was recorded before first spray, ten days after first spray and ten days after second spray using 0-9 rating scale and per cent disease index (PDI) was calculated using the formula given by wheeler (1969).

$$PDI = \frac{\text{Sum of all disease ratings}}{\text{Total number of leaves observed x maximum disease rating}} \times 100$$

Table 1. Disease rating scale.

Grade	Per cent disease severity with description
0	No symptoms on leaves
1	Small powdery spot-on leaves covering one per cent or less leaf area
3	small, scattered Powdery lesions on leaves covering 1-10% of leaf area
5	bigger Powdery lesions, covering 11-25% of leaf area
7	bigger coalescing Powdery patches covering 26-50% of leaf area.
9	Powdery growth covering 51% or more of leaf area, white coating on petioles, flowers and pods resultingin its shedding, reduced pod set.

RESULTS AND DISCUSSION

Efficacy of fungicides against Cercospora leaf spot

The trial was conducted at two locations *i.e.* Pulses Research Unit, Dr. PDKV, Akola. *In vivo* evaluation of chemicals against *Cercosporaconescens*are evaluated to control the Cercospora leaf spot of mungbean along with untreated control under natural field conditions. The data presented in Table 1 indicated that minimum intensity (2.97%) was recorded in the treatment T_6 *i.e.*, Foliar spray of combination product of Metiram + Pyraclostrobin WG (0.3%) and this was found significantly superior over all other treatment. Disease intensity as recorded in control was 33.27 per cent in first year. In 2nd year data, least *Cercospora* leaf spot disease intensity (5.60%)was obtained in the treatment T_6 *i.e.* Foliar spray of combination product of Metiram + Pyraclostrobin WG (@0.3%) which was followed by Treatment T3 *i.e.* 8.45 per cent. The disease intensity as recorded in control was 32.35 per cent. *Cercospora* leaf spot disease intensity recorded was least in the treatment T_6 (5.60 %) *i.e.* foliar spray of combined product of Metiram + Pyraclostrobin WG (0.3 %) whereas the disease intensity recorded in control was 30.95 per cent in third year.In pooled data minimum intensity of *Cercospora* leaf spot disease 4.66 per cent was recorded in Treatment T_6 *i.e.* foliar spray of combination product of Metiram + Pyraclostrobin WG (0.3%) which was followed by Treatment T_3 *i.e.* foliar spray of Propiconazole (@ 0.1%) and T_4 *i.e.* foliar spray of Hexaconazole (@ 0.1%) 7.74% and 8.68 per cent disease intensity respectively (Table 1). In respect of yield, 1st year, 2nd year and 3rd year and pooled yield was obtained highest *i.e.* 1173.30 Kg ha^{-1}, 1211.50 Kg ha^{-1}, 1196.56 Kg ha^{-1} and 1193.67 Kg ha^{-1}, respectively in the treatment T_6 (Metiram + Pyraclostrobin WG, 0.3 %) whereas, minimum yield recorded in control was 843.30 Kg ha^{-1}, 838.70 Kg ha^{-1}, 829.58 Kg ha^{-1} and 649.79 Kg ha^{-1}, respectively. (Table 2).Corresponding results were reported by Huma *et al.* (2020) that is metiram and pyraclostrobin (0.3 %) was found effective in restricting the mycelial growth (6.60 mm & 3.20 mm) of *Cercosporacanescens* on mungbean at 100 and 200 ppm. Huma *et al*. (2020) observed that minimum disease index (0.9) and maximum disease control (70.1 %) in the foliar application of carbendazim (12 %) + and mancozeb (63 %)

Table1: Per cent disease intensity of *Cercospora* leaf spot of Mungbean (Akola location)

S.N.	Treatments	PDI*Cercospora* leaf spot			
		1st Year	2nd Year	3rd Year	Pooled data
T1	Foliar spray of Carbendazim 50 WP (0.1%)	6.47	17.10	16.80	13.45
		(2.54)*	(24.37)*	(24.19)*	(21.52) *
T2	Foliar spray of Tebuconazole 25EC (0.1%)	4.90	10.68	10.65	8.74
		(2.21)	(19.06)	(19.04)	(17.20)
T3	Foliar spray of Propiconazole 25EC (0.1%)	6.30	8.45	8.48	7.74
		(2.51)	(16.88)	(16.93)	(16.15)
T4	Foliar spray of Hexaconazole 5EC (0.1%)	4.70	10.79	10.55	8.68
		(2.17)	(19.16)	(18.95)	(17.14)
T5	Foliar spray of Mancozeb 75WP (0.2%)	9.03	14.71	14.24	12.66
		(3.01)	(22.54)	(22.17)	(20.84)
T6	Foliar spray of Metiram 55 % EC +	2.97	5.60	5.42	4.66
	Pyraclostrobin 5% WG (0.3%)	(1.72)	(13.61)	(13.46)	(12.47)
T7	Untreated check	33.27	32.35	30.95	32.19
		(5.77)	(34.65)	(33.80)	(34.57)
	S.E. (m)	0.3	0.79	0.79	0.57
	C.D. at 5 %	0.9	2.24	2.44	1.76

*Arc sign transformed value

Table2: Effect of various treatments on yield (Akola location)

S. N.	Treatments	1st Yield	2nd Yield	3rd Yield	Pooled Yield
T1	Foliar spray of Carbendazim 50 WP (0.1%)	1038.30	915.20	891.11	765.32
T2	Foliar spray of Tebuconazole 25EC (0.1%)	1091.70	1079.05	1064.97	835.97
T3	Foliar spray of Propiconazole 25EC (0.1%)	1080.0	1140.55	1070.67	857.07
T4	Foliar spray of Hexaconazole 5EC (0.1%)	1146.70	1098.80	1056.31	845.78
T5	Foliar spray of Mancozeb 75WP (0.2%)	956.70	924.70	902.92	761.87
T6	Foliar spray of Metiram 55 % EC + Pyraclostrobin 5% WG (0.3%)	1173.30	1211.50	1196.56	1193.67
T7	Untreated check	843.30	838.70	829.58	649.79
	S.E. (m)	45.0	16.36	17.95	10.90
	C.D. at 5 %	136.30	46.84	55.28	33.57

75 WP at 0.2% concentration.Muhammad *et. al.* (2014)recorded highest PDI in control (40.74 %) then minimum in Mancozeb (25.92%). Radiomil Gold (18.51 %) and Antracol (18.52%) Lowest disease incidence (5.87 %) was found in carbendazim 50% + fluazinam 600 WP. (Eva *et al.*,2016).

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Design and Development of Small Tractor Drawn Sprayer

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ABSTRACT

A small tractor operated sprayer developed at the Department of Farm Power and Machinery Dr. PDKV, Akola on the basis of agronomical parameters, functional requirement, physical and economic considerations. Agronomical requirement included type of crop, variety, row spacing, plant canopy and height of crop. Functional requirement includes wheel track, capacity of tractor, pressure in nozzle, number of nozzles and different arrangement of boom. Physical and economical consideration taken in account as simplicity of design, durability, low cost, use of locally available material, and maintenance cost. The small tractor 18 hp was used as source of power to operate sprayer. The 1.5hp triplex pump with 800 psi pressure was selected for the development of sprayer.PVC tank available in the market of 225 liter capacity was selected to develop sprayer. Power transmission system has been developed to perform intended function.A 6 m boom was fabricated from the square hollow pipes. The calculated discharge 0.9 lpm, available hollow cone nozzle of ASPEEmake was selected for boom.

In Indian scenario near about 70,000 million rupees crops worth is lost every year from which near about 52 percent losses are caused by insects and diseases, 33 percent by weeds and 15 percent by rodents, birds and nematodes as reported by (Chetan, et, al., 2014).Now a day's change in the agricultural scenario of the country due to diversification in the cropping pattern and commercialization of agriculture. Also land is fragmented in small and marginal land holdings day by day, causing requirement of more efficient equipment's. At farm level, most of the farmers utilize various traditional equipments for crop protection sprays and weed control chemical applications. In field and orchard crops these chemicals are often distributed as liquid by manual sprayers or some of the farmers utilize motor operated stationary sprayers. The available tractor operated boom sprayers are costly and not affordable to the farmers. Some of the local manufacturers developed sprayers but they are not technically designed and do not fulfill the agro-technical requirements of different cropping patterns. Due to this the adoptability of such type of boom sprayers is very less in the region. The non-availability of labours in peak season, labour cost and non-availability of the improved spraying techniques matching with the agro-technical requirements of the various crops, cause delay in the operations. Due to this there is decrease in the production. The chemical control method of plant protection differs from physical, cultural, biological and genetic methods in its universal applicability and effectiveness with relatively low expenditure of labour and material.

Some past research was done on tractor operated boom sprayer, which works on horizontally mounted boom sprayer or as vertically mounted. This reduces the multiple utility of the sprayer in field and orchard crops causes additional cost required to the farmer and also restricts the use of sprayers in different cropping patterns. For getting more utility of the boom sprayer, the sprayer can be utilized for field and orchard crops. Also the boom can be utilized horizontally and vertically or capable to spray with spray guns in orchards as per the requirements. Due to improper design the operation leads to uneven uniformity of spray pattern which is one of the causes of low quality of the operation. Hodge et al. (1980) reported that the boom should be designed such that the time required for pack up and unpack as well as for raising and lowering would be minimum.Pochi and Vannucci (2002) found that the horizontal and vertical movements of boom sprayers are among the causes affecting the quality of distribution.To overcome the above problems present investigation was undertake to develop small tractor drawn boom sprayer.

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MATERIAL AND METHODS

Any type of mechanism requires the number of elements which are so designed that they carry with safety, the force to which they are subjected.Testing of machine involves the design of machine parts, so that they can perform their functions without failure or undue distortion.

One of the first points to be decided while designing a certain machine part is a material of which the part is to be made. The choice of the material is firstly governed, stressing and life of component. In addition to the requirement of concerning the shape and manufacture are to be considered next.

Design of the sprayer

A small tractor operated sprayer developed on the basis of agronomical parameters, functional requirement, physical and economic considerations. Agronomical requirement included type of crop, variety, row spacing, plant canopy and height of crop. Functional requirement includes wheel track, capacity of tractor, pressure in nozzle, number of nozzles and different arrangement of boom. Physical and economical consideration taken in account as simplicity of design, durability, low cost, use of locally available material, and maintenance cost.

Selection of power source

At first the power was taken from PTO of the tractor to rotate the hydraulic triplex pump with the help of belt and pulley. The power available with the prime mover is the important parameter to operate the spray pump and carry the sprayer unit in the field. As per available tractor power the fallowing requirement will meet out to develop various components of the sprayer. Available power on the small tractors is in the range of15-24 hp.Assumed efficiency of the engine is to be 80 %.(By considering tractor transmission and other losses 20%).Therefore power available = (15 to 24) x 0.8 = 12to 19.2 hp

Hence the available power on small tractor to develop a spray is in the range of 12 to 19.5 hp.

Structural frame analysis

The main frame was analyzed by using Finite Element Method (FEM) and CATIA software for the values of field variables i.e. displacement in case of stress analysis at each node of each elements of the main frame. The hitch pyramid of the main frame was fix point of the sprayer when in operation. The total load applied on the frame was 3000N. In the present analysis, the geometry of the structural frame is modeling using commercial available CATIA software. The structural frame was considered as beam element and was meshed. The materialproperties used for the fabrication of frame are shown in table 1.

Table 1 : Material properties of structural frame

S. N.	Particular	Physical properties
1	Young's modulus	178 GPa
2	Poisson's ratio	0.291
3	Density	7870kg/m^3
4	Coefficient of thermal expansion	1.21e-005/kg
5	Factor of safety	2
6	Allowable stress for Iron	480 MPa

Assigning boundary condition in the static structure analysis involves constraining six degree of freedom system (Three translation and three rotation) of the three point linkages of the structural of relevant nodes and the application of force applied in the mass node created at the C.G, of the frame structure mounted on the tank.

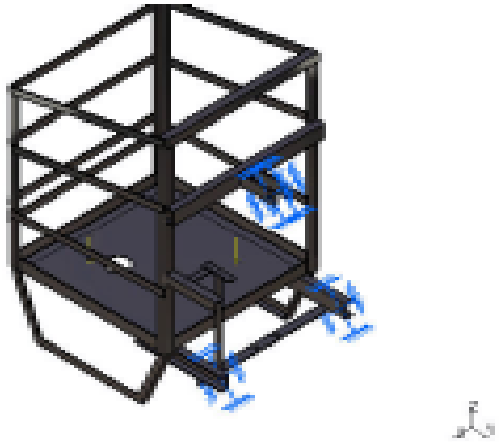

Fig.1. View of fixed points of the main frame.

Design of power transmission system

Most of the tractors have PTO speed of 540 rpm. The speed was measured on normal starting of the tractor and was observed 300 rpm. From this observed as 300 rpm further the speed is increased at pump shaft by utilizing belt and pulleys. To get more arc of contact driver pulley, a diameter 30 cm was selected with velocity ratio 2.83. Considering the power transmission of 1.5 hp pump with 900 rpm the belt and pulley power transmission system was developed as given below.Assuming diameter of driver is 30cm.

$$\frac{N_2}{N_1} = \frac{D_1}{D_2} \quad \text{..... (1)}$$

Where,

D_1 = Diameter of first driver pulley, cm

D_2 = Diameter of first driven pulley, cm

N_1 = Speed of first driver pulley, rpm

N_2 = Speed of first driven pulley, rpm

The rpm required to operate the pump is 900rpm for spraying operations and the observed engine rpm at nominal speed is 300 rpm. The driver pulley available in the market of double grooved pulley for V type belt was selected of 30 cm diameter for proper grip. Hence, diameter of driven pulley was determined as given below

D_1 =30cm, N_1=300 rpm,N_2=850rpm.

Therefore, the diameter of driven pulley, (900)/(300)=(30)/(D_2) so, D_2=10 cm.

Hence, the available double grooved pulley in the market for v-belt was selected of size 10.00 cm diameter and for driver pulley size was 30cm.

Design of shaft

A Shaft is rotating machine element which is used to transmit power from one place to another. The power is delivered to the shaft by tangential force and resultant torque (or twisting moment). The shaft may be designed on the basis of strength, rigidity and stiffness.

Tension in tight and slack side for pair of pulley, T_1 and T_2

Also,

$$\frac{T_1}{T_2} = e^{\mu\theta}{}_{\varepsilon} \quad \text{..... (2)}$$

$$\sin\alpha = \frac{(D_1 - D_2)}{2x} \quad \text{..... (3)}$$

Where,

$e^{\mu s}$ = Coefficient of friction (0.3 for rubber belt)

α = Angle of contact, radians

D_1 = Diameter of first driver pulley, inch

D_2 = Diameter of first driven pulley, inch

$$\text{Sin}\,\alpha = \frac{(0.304 - 0.104)}{2 \times 0.53} \quad \text{..... (4)}$$

Therefore,

$= 0.191°$cso, $\alpha = 11°$c

$$= 180 - 2a = 180 - 2 \times \frac{\pi}{180} = 2.75$$

radian Putting this value in Eq. no (2)

$$\frac{T_1}{T_2} = e^{(0.3 \times 2.75)} \quad \text{..... (5)}$$

$T_1 = 2.28\ T_2$ ….(6)

Putting value of T_1 in Eq. no (1)

$(2.28\ T_2 - T_2) = 10.03$

$T_2 = 7.69$ N, Also, $T_1 = 2.28 \times 7.69 = 17.53$ N

Total tension on belt $T_1 + T_2 = 25.22$ N

$$\text{Velocity of belt } V = \frac{\pi DN}{60} \quad \text{..... (7)}$$

Where,

V = Velocity of belt, m/sec

D = Diameter of pulley, inch

N = No, of revolution of shaft, rpm

$$= \frac{3.14 \times 0.304 \times 300}{60} = = 4.7 \text{ m/sec}$$

Maximum tension in belt, $T = \sigma X b X t$ ... (8)

Where,

T = Maximum tension in belt, N
b = Width of belt, m
σ = Shear stress in belt, 2 x 10^6N/ mm^2
t = Thickness of belt, m

= 2x10^6 x 0.016 x 0.01 = 320 N

Centrifugal tension in belt,

$T_C = mv^2$ ... (9)

Where,

T_C = Centrifugal tension in belt
m = Mass of double belt, 0.26 kg
T_C = 2.16N

Maximum tension in belt

$T = T_1 + T_C$ ... (10)

T_1=317.8N

From equation no.(4)

$317.8 = 2.28T_2$

T_2=139.40N

Power transmitted by shaft

$P = (T_1 - T_2) X V$ ... (11)

= (317.8-139.40) X 4.7=838 watt

Torque transmitted by shaft, $T = \frac{P \times 60}{2\pi N} = \frac{838 \times 60}{2 \times \pi \times 300} = 26702$ N-mm

Since pulley mounted in middle of main shaft

Therefore bending moment of shaft, $M = \frac{WXL}{4}$ ... (12)

$= \frac{457.2X350}{4}$

W=T_1+T_2=317.8+350=457.2N

Put above value in Eq.

Maximum bending moment of main shaft (M_m)

M_m= 39987.5 N-mm

There for equivalent torque (T_e) is given by

$$T_e = \sqrt{T_m^2 + M_m^2} \quad \text{... (13)}$$

Where,

T_e = Equivalent torque of shaft, N-mm
M = Bending moment of shaft, N-mm
T = Torque in motor shaft, 26.15 N-mm

$$T_e = \sqrt{39987.5^2 + 26702^2}$$

T_e=48083.2 N-mm

Let us take factor of safety to be 3

T_e = 48083.2 x 3 = 144249.6N-mm

We also know that equivalent twisting moment,

$$T_e = \frac{\pi}{16} \times \sigma_a \times d_m^3 \quad \text{....(14)}$$

$$d = \sqrt[3]{\frac{T_e \times 16}{\pi \times \sigma_a}} \quad \text{.....(15)}$$

Where,

d = Diameter of motor shaft, mm
σ_a = Allowable stress, 56 N/mm^2

$$d = \sqrt[3]{\frac{144249.6 \times 16}{3.14 \times 56}}$$

d= 23.59 mm

Also, check for equivalent bending moment (M_e) is given by,

$$M_e = \frac{1}{2}\left[M_m + \sqrt{(M_m^2 + T_m^2)}\right] \text{... (16)}$$

Where,

M_e= equivalent bending moment, kg-cm
M = Bending moment of shaft, kg-cm
T = Torque in shaft, kg-cm

$$M_e = \frac{1}{2}\left[39987.5 + \sqrt{39987.5^2 + 26702^2}\right]$$

M_e = 37392.6kg-cm

Let us take factor of safety to be 3

$M_e = 37392.6 \times 3 = 112177.8$ kg-cm

Now,

Equivalent bending moment

$$M_e = \frac{\pi}{32} \times \sigma_b \times {d_m}^3 \ldots (17)$$

$$\text{Also, } d_m = \sqrt[3]{\frac{M_e \times 32}{\pi \times \sigma_b}} \ldots (18)$$

Where,

M_e = equivalent bending moment, kg-cm
σ_b = allowable tensile stress, (for steel 56 kg/cm^2)
d = diameter of motor shaft, cm

$$d_m = \sqrt[3]{\frac{112177.8 \times 32}{3.14 \times 56}} = 27.33 = 27 \text{ mm}$$

As the diameter of bending moment is higher side i.e. 27.33 mm than the twisting, hence by considering the safety the diameter of 30 mm for the solid shaft mild steel material was selected.

Length of open V- belt drive

For transmission of power from pump shaft to counter pulley shaft an open v belt drive mechanism was used. Let the drive pulley D_1 = 30.48 cm and thepump pulley D_2 = 10.16 cm and the center to center distance between these pulleys is 30 cm. Hence the length of belt is given by

$$L = 2C + \frac{\pi}{4}(D_1 + D_2) + \frac{(D_1 - D_2)^2}{4C} \ldots (19)$$

Where,

D_1 = Diameter of main shaft pulley, cm
D_2 = Diameter of pump shaft pulley, cm
C = Center to center distance between pulleys, cm

$$L = 2 \times 30 + \frac{3.14}{4}(30.48 + 10.16) + \frac{(30.48 - 10.16)^2}{4 \times 30}$$

= 79.39 cm =80 cm

Hence a V belt was selected of 800 mm in length for which a standard size of the belt of size B-65 was selected from the market.

Boom width

The width of boom has influence on the effective field capacity. Large boom has swings at its end side which affects inefficient spray due to fluctuations in the target height above the crop. The number of nozzles and nozzles spacing are decided on the basis of boom width. A boom width was calculated by using the following formula. The length of boom was determined by following formula

$$L = \frac{TFC \times 10}{S} \ldots (20)$$

Where,

L = boom width, m
TFC = Theoretical field capacity, ha/h
S = Travel speed, km/h.

Assuming

TFC = 2.1ha/h and S = 3.5 km/h

$L = \frac{2.1 \times 10}{3.5}$ = 6.0 m,hence length of boom was taken as 6 m.

Nozzle

Nozzle is the most important component of spray machine. The type of nozzles depends on type of pesticide, weedicide or fungicide need to be sprayed. The most commonly used nozzle on boom sprayers is hollow cone nozzle. For effective application of pesticide there was need to find number of nozzles to be fitted on the boom at the proper spacing and it is calculated by using the following formula. For this purpose the following necessary assumptions are taken.

Assumption:

Height of boom above target (h): 60.96 cm

Cone angle (ø):80^0

Spray Overlap (S): 30 %

Operating pressure of nozzle: 42.27 psi

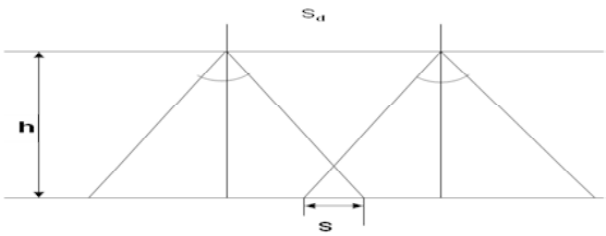

Fig 2: Spacing between two nozzles

Where,

S_d = Nozzle spacing, cm

h = Height of boom above target, cm

Ø = Cone angle, degree

S = spray overlap, per cent

For determination of distance between two nozzles following equation is used

$$h = 0.5X\frac{1}{\tan\theta/2} X \frac{Sd}{1-(S/100)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (21)$$

Putting above value in Eq. 21

$$Sd = 0.5x \frac{1}{0.84} X \frac{60.96}{0.7}$$

From equation Sd= 37.72 cm say 38.0

Hence

$$n = \frac{L}{sd}$$

Where,

η = Number of nozzle

L = Length of boom, mm

sd = Spacing between two nozzle, mm

= 6000/380= 15.78 say 16

Hence, 16 nozzleswere fitted on the boom at 38 cm spacing between the adjacent two nozzles. As the pump has two outlets, the 8 nozzles are placed at two separate delivery line from the center of boom to right and left side end.

Pump selection

Selection of the pump depends upon the available power and discharge rate of boom. In general 1 to 5 hp pumps with various capacities are available in the market.As the power available from small tractor in the range of 12 to19.5 hp.We can use 80% of the available power source with considering the small tractor1.5hp triplex pump was selected with 800 psi pressure suitable to conceptual design.

The pump was selected from the market with available models and the detail specifications are given below table 2.

Table 2 : Specifications of HTP pump.

S. N.	Particulars	Specification
1	Model	Asian Gold
2	Revaluation	900
3	Suction	22lpm
4	Pressure	30 Kg/cm2
5	Power	1.5hp

As the selected model of 1.5hp was used for discharge rate of 24 lpm at 900 rpm,hence actual discharge of the pump with assuming 80 % pump efficiency. 75 % of the pump discharge will be delivered to boom and 25 % will be delivered to agitating the spray solution in the tank. Keller and Karmeli (1974).

Therefore,discharge to boom Q = 14.4 lpm

Hence nozzle discharge 14.4/16 = 0.9 lpm at 42.27 psi

Matching to the calculated discharge 0.9 lpm, available hollow cone nozzle of ASPEE make was selected for boom.

Spray Guns

The spray guns were used when the boom sprayer did not able to spray due to row and plant spacing with their canopy. Sometimes the plant canopy was to dense like in cotton and orchard crop and the boom along with the prime mover could not operate in the field. Therefore the spray gun was selected from the market to spray the liquid where the boom cannot work reachabove the target.

Selection of tank

The sprayer solution kept in tank of sprayer which should be corrosion resistant, easy to fill and clean. The sprayer tank mounted on frame and for spraying particular field must be properly designed. For this purpose, tank capacity of sprayer is determined by following formulas.

Tank Capacity

$$Q_t = D_b \times t \ldots \quad (22)$$

Where,

Q_t = Tank Capacity, liters

D_b = Total discharge rate of all nozzle of the boom l/min

t = duration of use, minutes

D_b = 14.816 lit/min

t = 14 min

Q_t = 207lit

Hence a PVC tank available in the market of 225 liter capacity was selected.

Agitation

For proper functioning of sprayer the agitation must be properly according to tank capacity. So the following formula is used.

Usually use 5 to 10 percent of the tank capacity for agitation (Keller and Karmeli, 1974).

$$Q_a = (0.10\text{-}0.05)\ Qt \quad \ldots (23)$$

Where,

Q_t = tank capacity .liters

Q_a = Agitation required, lpm.

$=(0.10\text{-}0.05)\,200=10$lpm

Hose pipes

The nylon pipe was selected for mounting of the nozzles. The inner thickness of the hose pipe was 20 mm with a bearing pressure 150 kg/cm^2.

RESULTS AND DUSCISSION

The experimental findings obtained from the present study have been presented in following heads. Any type of machine requires the number of element which are so designed that they carry with safety, the force to which they are subjected. The analysis of force involves the design of machine parts, so that they can perform their function without failure of undue distortions.

The strength, durability and service of farm implements or machinery depend largely upon the selection and quality of material used in its manufacturing. The choice of the material is important factor in the manufacturing process concerning the material is governed by following important considerations.

i) Suitability of the material for satisfactory working conditions during services.

ii) Amenability of material to the process required in marketing the component.

iii) Cost of material in relation to selling price of component, machine or implement

iv) Should be simple and of low-cost as most of the farmers lack capital for expensive machinery and their maintenance.

v) There is tendency in a construction of an implement or machinery to eliminate as many casting as possible and to use pressed stamped and tubular steel. The cost of manufacturing machinery and the weight of machine is reduced, the strength and durability is retained and often improved. The success or failure of machine invariably depends upon the material used in the in its fabrication.

Main frame

The material used for the fabrication of frame was Mild Steel "L" section of 40x40x5 mm size, "C" section for main base and hitch pyramid was used of 40x40x5 mm size. Whereas the supporting flat of M. S. 40x5 mm size and the base sheet for a tank support was fabricated from M. S. 2.5 mm sheet. The overall dimension of the main frame was 740x730x1200mm.The control valve with pump was mounted on the main frame. The boom slider was attached back side of the main frame.

Bottom of frame

Bottom of frame supports and hold tank and act stand of sprayer. It was fabricated using the M.S angle of the size 40x40x5mm.The length of the bottom frame was 770mm and width of 760mm.The main frame was welded by the electric arc welding whereas boom stand mounted on it with helps of nut and bolts.

Von mises stress for mild steel mainframe.

The equivalent von mises stress plot is obtained by CATIA analysis software which shows a maximum stress 13.091 MPa.

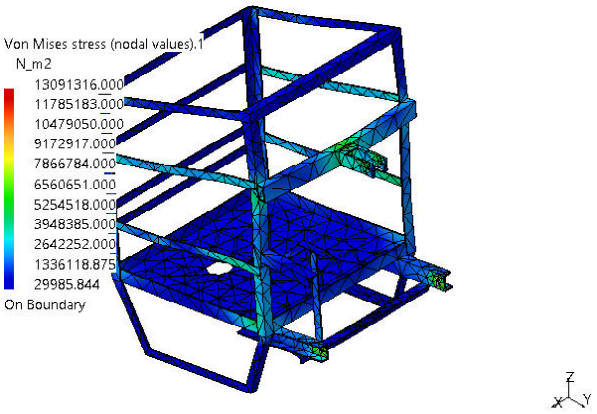

Fig. 3 Von mises stress of main frame

The stress is mainly concentrated at hitch pyramid sections where the tractor three point linkages are attached. The von mises for nodal values of the main form are depicted in fig 4.

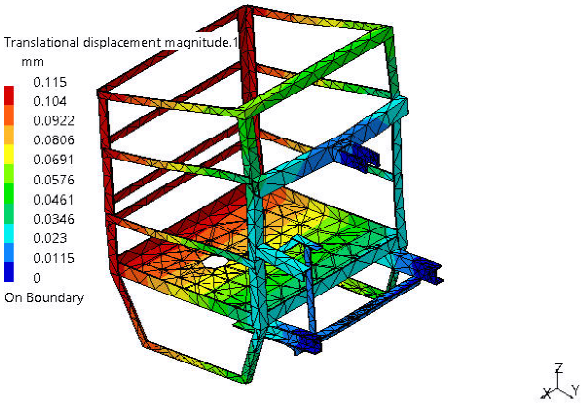

Fig. 4 Translational displacement of main frame

The displacement under the given load is depicted in fig. 4.

Which is maximum at back portion of the frame which is shown by the red area where the maximum displacement is 0.115 mm. The factor of safety for the given material was found out manually by dividing the yield strength with respect to the equivalent maximum stress in the material i.e. Yield strength of the mild steel is 200 MPa and the maximum stress in the martial is 13.091 MPa. Hence the factor of safety is obtained which is equal to 15.27. Considerable factor of safety or design factor is applied to the frame elements to minimize the risk of failure. This factor of safety value implies the safe value of applied load and deformation

Boom

A boom is fabricated from the square hollow pipes. The length of boom was taken as 6m from calculated values. The boom is fabricated in three segments one for slider and other two side parts attached to the ends of slider. From these two slider attachments ends the boom can be folded horizontally or vertically for spraying operations and gather on each other for transportation. The square hallow pipes were selected for low weight and to easily fit the nozzles with sliding clamps. The Fig. 5 and Fig. 6 shows the front view and left side view of boom sprayer.

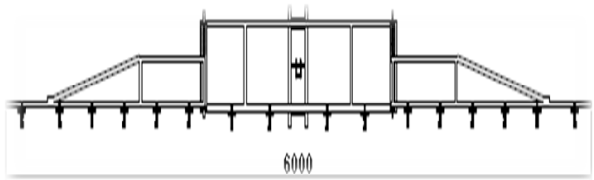

Fig.5 Frontview of boom

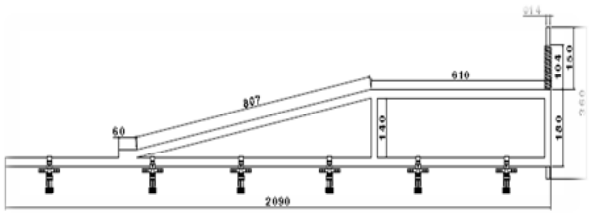

Fig.6 Left side boom segment of boom sprayer

Boom stand

It is a part of main frame which helped in guiding the vertical movement of the boom to adjust spraying height. It was fabricated from M.S angles of 40x40x5mm size. The total height of the boom stand was 1340mm from the ground.

Boom slider

A boom slider was used to use to lower or upward movement of the boom without any nut and bolt

arrangement to set the height of boom above the target crop. A boom slider is developed by using "c" channels is attached to the main frame and other part is attached to the main frame and other part attached to the center of the boom. A hinge is provided to automatically lock on the round bars of the boom slider on main

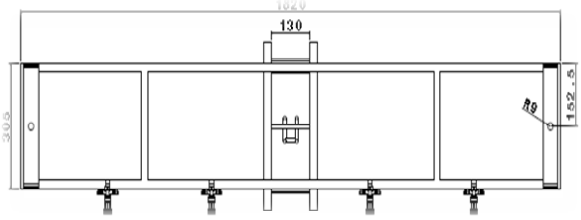

Fig. 7 Slider of boom sprayer

Boom folding arrangement

The folding boom carries the nozzle and distribution pipes. The frame is horizontally sprayed for field crop and also vertically spread for orchard crop. It was fabricated from M.S square pipe of section 40x40x5mm.

Table 1 Specifications of tractor operated sprayer

S.N.	Technical descriptions	Boom sprayer
1	Tank capacity	225 lit
2	Working pressure	250kpa
3	Maximum pressure	3000 kpa
4	PTO	300 rpm
5	Pump capacity	18 hp minimum24 lpm, 900-950 rpm, Maximum pressure 800 PSI,3.5 Hp
6	Gross weight of sprayer (without water)	100 Kg
7	Type and no. of nozzles used	Hollow cone nozzles, 16

Plate 1. Prototype small tractor operated sprayer

The tractor operated boom sprayer was fabricated by standard technique. The specifications of this sprayer is shown in Table 3. The developed sprayer is shown in plate 1.

CONCLUSION

From the study following conclusion could be drawn

* As the equivalent von mises stress plot is obtained by CATIA analysis software which shows a maximum stress 13.091 MPa.
* Available power to develop small tractor operated sprayer is in the range of 12 to 19.5 hp and it is sufficient to operate sprayer.
* Boom can be easily adjust vertically and horizontally also.

LITERATURE CITED

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Development and Performance Evaluation of Tractor Operated Cotton Stubble Up-rooter Attachment for Shredder

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ABSTRACT

The cotton stalks are leftover after picking of cotton from the field, and these stalks traditionally burned which has effect to increase carbon dioxide to atmosphere and causes global warming. Shredders are available commercially which cut the cotton stalks above the ground level but left standing stubbles 180 to 285 mm in height in the field. A tractor operated cotton stubble up-rooter attachment for shredder was developed to solve the issue of cotton stubble uprooting and its management. The equipment was tested in the field to evaluate draft requirement, cotton stubble uprooting efficiency, wheel slippage, fuel consumption and width of stubble uprooting. The field trials were undertaken on various combinations of uprooting depth viz., 150, 200 and 250 mm and forward speeds viz., 1.5, 2.5 and 3.5 km h^{-1}. It was observed that a depth of 200 mm was found sufficient to remove cotton stubble at forward speed of 2.5 km h^{-1}. An average draft requirement, cotton stubble uprooting efficiency, wheel slippage, fuel consumption and width of stubble uprooting were found to be 653.5 kgf, 98.08 per cent, 12.81 per cent, 6.49 lit h^{-1} and 360 mm, respectively. An actual field capacity of cotton stubble up-rooter was found to be 0.22 ha h^{-1}. A tractor operated cotton stubble up-rooter attachment for shredder is recommended for cotton crop residue management.

Cotton is an important cash crop produce mainly in Akola, Amravati, Yavatmal, Wardha and Nagpur districts in Vidarbha region of Maharashtra. Different machinery and methods are being used for removal of cotton stalks after cotton picking. In India, most of the stalks are removed from field by pulling manually and burnt it in the field and which is harmful to the environment. Tractor operated V-blade, plough and harrow are being used to process these stalks. The various passes of tractor drawn machinery consume fuels for its operation which increased the cost of operation. Tractor operated shredders are available and being used for crop residue management but it shredded the stalks at certain height and hence standing stubble are available as such in the field.

Major difficulty in cotton crop production is a clearing of field after picking. Burning residues leads to a wide range of problems, such as the release of soot particles and smoke which leads to human health problems, emission of greenhouse gases, such as carbon dioxide, methane and nitrous oxide leading to global warming and loss of plant nutrients (Bhuneshwari *et al*., 2019). Retention of cotton stalk on surface instead of burning help to conserve moisture, control weeds and nutrients therefore, it helps to maintain moderate soil temperature. Conservation of agriculture had impacted for residual management of several crops to avoid burning of crops which leads to air pollution. The left-over cotton stalks are generally pulled by stalk puller traditionally, and it demands considerable amount of labour, drudgery and more time to remove stalk. The shortage and unavailability of labour for picking delay seed bed preparation (Cevdet *et al*., 2010).

Shredding of stalk is partial solution for residual removal hence uprooting must be done to take out the whole stalks with roots from the field. Shredders are generally used, for removing the crop residues from agricultural field. Shredding of crop can be done in a short period of time and it leads to early decomposition of the crop residue in field which increase soil nutrient content but standing stubbles are still leftover in the field.

A tractor operated cotton stubble shredder is used for shredding cotton stalks in the field. The cotton stubble up-rooter attachment uprooted cotton stubble followed by shredding of cotton stalks in a single operation. Uprooted stubbles buried in the soil by

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inversion of furrow slices by uprooting attachment. The furrow slice rides along the curvature and pulverized to some extent before being thrown. The cotton stubble up-rooter arrangement helps to prepare land early for next crop. The shredded stubbles are mix in field and which is a source of biomass and helps to conserve soil as well as water. The complete biomass of cotton crop remains in field as conservation agriculture. Disc blade can be forced to penetrate into soil, which can be works well in sticky soil and for deep uprooting of stubbles. In view of mechanization, cotton stubble up-rooter attachment for shredder solved the issue of cotton crop residue management problem in the field. Therefore, tractor operated cotton stubble up-rooter attachment for shredder was developed for cotton crop residue management in the field.

MATERIAL AND METHODS

A tractor operated cotton stubble up-rooter attachment for shredder was developed for cotton crop residue management in Dr. Panjabrarao Deshmukh Krishi Vidyapeeth, Akola (M.S.). Views of cotton stubble up-rooter attachment mounted on tractor operated shredder is shown in Fig. 1.

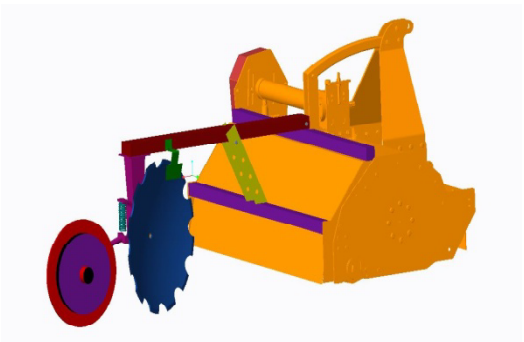

Fig.1 Cotton stubble up-rooter attachment mounted on tractor operated shredder

The overall size of the shredder was 1836 x 1234 x 1315 mm and main frame of 1030 x 100 x 60 mm oriented horizontally was welded at middle of the frame of shredder. The depth adjustment channel 360 x 8 x 8 mm was vertically adjusted below the horizontal main frame containing holes of 25 mm diameter and stopper arrangement for adjusting depth of disc blade. Notch disc blade of 650 mm diameter and 12 notches was fitted to the horizontal main frame. Furrow wheel and scraper were fitted to the disc blade unit. Notch disc blade was used in the experiment because it is used in trashy conditions and hard soil. The serrated edges of the notch disc help in cutting remainders of crop and weeds. Notch disc blades penetrate better than smooth blades as the weight being spread over less area which helps to up-root stubble. The performance of cotton stubble up-rooter attachment was evaluated in the field with the observations and determination of the parameters of forward speed, working width of uprooting, effective field capacity, theoretical field capacity, field efficiency, depth of uprooting, fuel consumption, draft requirement, wheel slippage, number of stubbles before uprooting, number of stubbles after uprooting, and uprooting efficiency (Ramadan, 2010).

The theoretical field capacity of tractor operated cotton stubble up-rooter attachment was determined by considering working width and traveling speed of the machine and it was determined by the Eq. 1.

$$T.F.C. = \frac{S \times W}{10} \quad .....(1)$$

Where,

T.F.C - theoretical field capacity, ha/h

W - theoretical width of Implement, m

S - speed of operation, km/h

The effective field capacity of tractor operated cotton stalk up-rooter attachment was the time consumed for actual work and lost for other activities such as turning and break downs and effective actual field capacity was calculated by Eq. 2.

$$E.F.C. = \frac{A}{T_p + T_1} \quad ..... (2)$$

Where,

E.F.C - effective field capacity, ha/h

A - area, ha

T_p - productive time, h

T_1 - non-productive time, h

The field efficiency of tractor operated cotton stubble up-rooter attachment for shredder was determined by taking the ratio of effective field capacity to theoretical field capacity and it was calculated by Eq. 3.

$$FE = \frac{EFC}{TFC} \times 100$$

Where,

FE - field efficiency, %

EFC - effective field capacity, ha/h

TFC - theoretical field capacity, ha/h

For calculating forward speed of tractor equipped with cotton stubble up-rooter attachment for shredder, the two poles 20 m apart were placed approximately in the middle of the test run. The forward speed was calculated from the time required for the tractor to travel the distance 20 m between two poles. Average of such reading was taken to calculate the forward speed of the tractor and calculated by Eq. 4.

$$S = \frac{L}{t} \quad \text{..... (4)}$$

Where,

S - forward speed of the machine, m/s

L - distance traveled, m

t - time taken, s

The tractor with shredder and uprooting attachment was placed on the leveled ground. To measure the fuel consumption, the fuel tank of the tractor was filled up to top of the tank before the operation and after the completion of the operation tractor was placed at a leveled ground and then the tank was again refilled with fuel to maintain the original level of fuel. The quantity of fuel filled in the tank was measured by measuring cylinder. The quantity of fuel required to make up the original level as before the operation was the actual fuel consumption.

A digital load cell was used for measurement of draft requirement of the machine. The 'X' tractor was positioned in front of the test tractor (Y) and the load cell was connected to the front axle of 'Y' tractor with wire rope and clamps. Wire rope and load cell was kept horizontal during the field trial and the implement was attached to the 'Y' tractor. The draft of cotton stubble uprooter was recorded in the field. For no-load reading, the uprooter was lifted and the draft was recorded, similarly, draft reading recorded while uprooter in operation. Throughout the observations the tractor 'Y' was kept in neutral position. The readings were noted after each run. The results of the draft requirement of uprooter were calculated by Eq. 5.

Draft, kgf = Draft with load – Draft without load ...Eq. 5

The number of the stalks present in one row of 10 m length were measured before uprooting one by one and noted down. Average number of stalks present in each row was counted before uprooting and it is given by notation S_1. The number of the stubbles leftover after the operation of shredding and uprooting were noted and average number of stubble present were counted after uprooting and it is given by notation S_2.

The shredder equipped with cotton stubble up-rooter was operated in the field maintaining required depth. Width of stubble uprooting was measured by taking the distance between the extreme left to extreme right of the uprooted soil by the cut of disc blade. Wheel slippage was calculated by counting the number of wheel revolution under load condition and without load condition and is given by Eq. 6.

$$\text{Wheel slippage, \%} = \frac{N_1 - N_2}{N_1} \times 100$$

Where,

N_1 - No. of wheel revolution under load condition

N_2 - No. of wheel revolutions at no load condition

The cotton stubble uprooting efficiency is given by Eq. 7

$$\text{Uprooting efficiency} = \frac{S_1 - S_2}{S_1} \times 100$$

Where,

S_1 - Number of stubbles before the operation

S_2 - Number of stubbles after the operation

RESULTS AND DISCUSSION

Draft requirement using load cell were measured at three different forward speeds viz., 1.5, 2.5 and 3.5 km/h, and at three different stubble uprooting depth viz., 150, 200 and 250 mm. Table 1 shows the mean values of draft requirement with respect to stalk uprooting depth and forward. An average draft requirement of uprooter was worked out to be 564.5, 578.3 and 591.6 kgf at forward speed of 1.5, 2.5 and 3.5 km/h, respectively while maintained uprooting depth of 150 mm. Similarly draft requirement of uprooter worked out at 200 mm working depth and found to be 641.2, 652.3 and 661.9 kgf at forward speed of 1.5, 2.5 and 3.5 km/h, respectively.

Table 1 : Average values of draft requirement at various uprooting depth and corresponding forward speed

S.N.	Depth, mm	Draft requirement, kgf		
		1.5 km h^{-1}	2.5 km h^{-1}	3.5 km h^{-1}
1	150	564.5	578.3	591.6
2	200	641.2	652.3	661.9
3	250	680.5	696.7	710.1

The draft requirement at 250 mm operating depth was worked out to be 680.5, 696.7 and 710.1 kgf at 1.5, 2.5 and 3.5 km/h forward speed, respectively. Linear increment in the draft requirement was observed at 150 mm uprooting depth when forward speed increased form1.5, 2.5 and 3.5 km/h.

Effect of cotton stubble uprooting depth and forward speed on cotton stubble uprooting efficiency of up-rooter equipped with shredder was studied. In 10 m length of field a total ten observations were taken at 150, 200 and 250 mm stubble uprooting depth and at 1.5, 2.0 and 2.5 km h^{-1} forward speed. Maximum cotton stalk uprooting efficiency was obtained at 250 mm stalk uprooting depth and 2.5 km h^{-1} forward speed that was 98.62 per cent and minimum efficiency was found at 150 mm stalk uprooting depth and 3.5 km h^{-1} forward speed that was 93.54 per cent (Sridhar and Surendrakumar, 2018; Senthilkumar *et al.,* 2010). The condition of the field after operation of cotton stalk up-rooter attachment is shown in Fig.2

Fig. 2 : Field condition after operation of cotton stubble up-rooter attached

The effect of stubble uprooting depth and forward speed on wheel slippage of cotton stubble up-rooter equipped with shredder was studied. Trials were taken to observe number of revolutions of rear wheel of tractor when under load condition (N_1) and at no load condition (N_2) at three different forward speeds viz., 1.5, 2.5 and 3.5 km/h and for at three different stubble uprooting depth viz., 150, 200 and 250 mm. Effect of cotton stubble uprooting depth and forward speed on fuel consumption of cotton stubble up-rooter equipped with shredder was studied. The fuel tank of the tractor was filled up to top of the tank before the operation and after the completion of the operation tractor was placed at a leveled ground and refilled to measure amount of fuel consumed. Fuel consumption was measured at 150, 200 and 250 mm, stubble uprooting depth and each for 1.5, 2.0 and 2.5 km/h forward speed shown in Table 2.

Table 2. Fuel consumption of cotton stubble up-rooter attachment for shredder at various uprooting depth and corresponding forward speed

S.N.	Depth, mm	Fuel consumption (l h^{-1})		
		1.5 km h^{-1}	2.5 km h^{-1}	3.5km h^{-1}
1	150	6.34	6.39	6.41
2	200	6.49	6.54	6.62
3	250	6.65	6.69	6.72

Maximum fuel consumption was obtained at 250 mm stubble uprooting depth and 3.5 km h^{-1} forward speed that was 6.72 l h^{-1} and minimum fuel consumption was found at 150 mm stubble uprooting depth and 1.5 km/h

Table 3. Width of stubble uprooting of cotton stubble up-rooter attachment for shredder at various uprooting depth and corresponding forward speed

S. N.	Width of stubble uprooting (mm)								
	150 mm			200 mm			250 mm		
	1.5 km h^{-1}	2.5 km h^{-1}	3.5 km h^{-1}	1.5 km h^{-1}	2.5 km h^{-1}	3.5 km h^{-1}	1.5 km h^{-1}	2.5 km h^{-1}	3.5 km h^{-1}
1	326	319	280	350	350	260	326	390	360
2	370	360	322	390	392	339	399	360	402
3	332	329	329	360	345	325	391	340	350
4	335	325	341	310	401	307	480	406	361
5	301	307	280	406	399	326	385	365	378
6	329	326	312	365	410	380	396	370	365
7	390	380	314	370	306	399	319	369	350
8	336	299	319	369	329	296	401	408	360
9	339	326	301	408	368	349	399	358	330
10	298	319	399	358	390	335	480	350	370
Avg.	331	326	314	369	355	343	387	371	359

forward speed that was 6.34 l/h. Width of stubble uprooting after each trial was measured using foot rule. Width of stubble uprooting at 150, 200 and 250 mm uprooting depth and corresponding forward speed is shown below in Table 3.

From Table 3, it is seen that average width of stubble uprooting at 150 mm uprooting depth and at 1.5, 2.5 and 3.5 km/h was found to be 331, 326 and 314 mm and at 200 mm uprooting depth it was 369, 355 and 343 mm. At 250 mm uprooting depth average width was found 387, 371 and 359 mm at 1.5, 2.5 and 3.5 km/h respectively. The uprooter was operated in black cotton soil and while operating in field, the more soil failure was observed and hence width of soil failure was found more.

From the study it was observed at 200 mm uprooting depth and 2.5 km/h forward speed the implement showed optimum results with 98.08 per cent uprooting efficiency. Even at 250 mm uprooting depth and 2.5 km/h forward speed it gave 98.62 per cent uprooting efficiency.

CONCLUSIONS

Cotton stalks shredding, stubble uprooting and strip ploughing, all these three operations were performed in a single pass of tractor. Cent-percent biomass was retained in the field and which helps to conserve moisture. Depth of operation of 200 mm was found sufficient for uprooting of 98.08 per cent cotton stubbles. The overall performance of tractor operated cotton stubble up-rooter attachment for shredder during the operation was found satisfactory.

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RESEARCH NOTES

Resource Use Efficiency in Dairy Entrepreneurship

In India, agriculture and allied sectors provide livelihood to about 70 percent of the population and contribute nearly fifteen percent of national income. The per capita available land is 0.30 hectare (Anon., 2011). The pressure exerted by over increasing occupancy on the land by increasing strength of population has been further reducing the per capita available land. It is insufficient for maintaining minimum standard of living hence, it is utmost necessary that, subsidiary agro-based industries or occupation must be tried by rural people to seek over the means for their survival.

As a subsidiary agro-based industry, dairy provide drought power and manures which augment the crop production, Milch animals are one of the solutions to solve the problem of uncertainty associated in family business. Dairy enterprise is marginally profitable and farmers have ample opportunities to increase output by using more feed and hired labour inputs. The family members (men, women and children) and paid labours share each other in most of the related in dairy entrepreneurship. Therefore, to bring improvement in dairy enterprise and rural life, self employment of rural family members could contribute in the improvement of dairy farming activities as well as rural life.

There is great variation in the productivity and resource use efficiency of different breeds of milch buffalo reared in different resource situation due to variation in genetic characteristics feeding and management practices. Ultimately, these resourcesaffect milk production. These resources have to be optimally utilized in order to get maximum income from dairy enterprise. Thus, present research study was under taken to provide guidelines for recognition of dairying by the improvement of dairy productivity in Amravati district in Maharashtra to cope with the object ofto study on resource use efficiency in thebuffalo milk production.

To study the resource use efficiency in buffalo milk production, the data was collected from 120 milk producers randomly in four tahasils in Amravati district through questionnaire. Out of which, 32 improved buffalo milk producers were selected for study.Resource use efficiency was calculated by using cobb-Douglus production function. The functional model is presented in the fallowing equation (Dharpal, 2013).

$$Y = a X_1^{b1} \times X_2^{b2} \times X_3^{b3} \times X_4^{b4} \times X_5^{b5} \times X_6^{b6} \times X_7^{b7} \times X_8^{b8} \times X_{79}^{b9} \times X_{10}^{b10} \times X_{11}^{b11} \times X_{12}^{b12} \times X_{13}^{b13}$$

The Function was fitted in logarithms. The transformed function is -

$$\text{Log}Y = \log a + b_1 \log X_1 + b_2 \log X_2 + b_3 \log X_3 + b_4 \log X_4 + b_5 \log X_5 + b_6 \log X_6 + b_7 \log X_7$$

$$+b_8 \log X_8 + b_9 \log X_9 + b_{10} \log X_{10} + b_{11} \log X_{11} + + b_{12} \log X_{12} + b_{13} \log X_{13}$$

Where

Y	=	Total receipt in rupees
X_1	-	Hired human labour(Rs)
X_2	-	Dry fodder (Rs)
X_3	-	Green fodder (Rs)
X_4	-	Medicines & vaccination (Rs)
X_5	-	Concentrate feed (Rs)
X_6	-	Grazing charges(Rs)
X_7	-	Watering (Rs)
X_8	-	Breeding (Rs)
X_9	-	Transportation of inputs (Rs)
X_{10}	-	Cleaning expenses(Rs)
X_{11}	-	Calcium dose(Rs)
X_{12}	-	Interest on working capital (Rs)
X_{13}	-	family labour charges (Rs)
a	=	Constant intercept which indicate the level of output when zero inputs are use.
b_1 to b_7	=	Production elasticity's partial regression coefficient of respective variables.

Above Cobb-Douglas production function is used for different variables and its results shown as resource use efficiency in the results and discussions.

The collected was tabulated by using Cobb-Douglas production functionfor different variables and its results shown as resource use efficiency in the buffalo milk production given in the following table.

S.N.	Variables	be-coefficient	SE-Standard	T (stat) Value
	Intercept (a)	1.6925	1.9143	0.8841
1	X_1-hired human labour	-0.0420	0.0328	-1.27
2	X_2-dry fodder	-0.3281	0.0400	-0.81927
3	X_3- green fodder	-0.01175	0.1543	0.0761
4	X_4 –medicines and vaccination	0.4414	0.2976	1.4831
5	X_5- concentrate feed	0.1509	0.3735	0.4040
6	X_6- grazing charges	-0.15159	0.25369	-0.59755
7	X_7- watering	0.00824	0.0401	0.02051
8	X_8-breeding charges	0.0203	0.0406	0.5012
9	X_9- transportation of inputs	0.07553	0.19011	0.3972
10	X_{10}- cleaning expenses	-0.0047	0.2083	-0.02286
11	X_{11}- calcium dose	0.0095	0.1053	0.090753
12	X_{12}- interest on working capital	0.3122	0.151288	2.0640
13	X_{13}-family labour charges	0.2671	0.23094	1.5696
14	R^2 (R- square)	0.4505		
15	Number of observations	32		

Above results about resource efficiency in the improved buffalo milk production shown that , value of partial regression coefficient were found positive in variables viz; medicines and vaccination (X_4), concentrate feed (X_5), breeding charges (X_8) , inputs transportation cost (X_9) , interest on working capital(X_{12}), and family labour charges(X_{13}) were, respectively as 0.4414, 0.1509, 0.0203, 0.07553, 0.3122 & 0.2671. On the contrary, value of partial regression coefficient were found negative in variables viz; hired human labour (X_1), dry fodder(X_2),green fodder(X_3),grazing charges(X_6),& in cleaning expenses(X_{10}) were respectively as -0.0420,-0.3281,-0.01175,-0.15159, and -0.0047. The maximum partial regression coefficient was observed in variable(X_4)medicines and vaccination where as the minimum value of partial regression was found in X_7- watering

Above results of regression coefficient in production function in respect f various resources used in improved buffalo milk production reflected that , medicines ,vaccination feed ,and labours explain 45% of variation in milk yield. (as shown in the table) The regression of coefficient of vaccination,concentrate feed, breeding and family labour charges were found positive and significant. However the milk yield elasticity withrespect to watering was very low. In this statistical analysis, it is cleared that, the responsiveness of milk output to proper medicines,vaccination, concentrate feed, familylabour and breeding charges was high. The hired human labour shown negative though not significant this may due to over employment of family labour in dairy business (Meena, 2012).

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Sarode, S.V. and U.S. Kulkarni, 1998. Sustanability of *Helicoverpa armigera* (Hubner) on weed partheninum hysterophorous, Indian J. Entomol., 60 (4) : 421-422

Kawarkhe, V.J., R.N. Jane and Manisha Deshmukh, 2003.Effect of nitrogen and specing levels on growth and flower yield of China Aster, PKV Res. J., 27 (2) : 163-165.

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