Vol. 45 No. 1, January 2021 ISSN 0378-813 X

# PKV RESEARCH JOURNAL


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PDKV Bullock Drawn Puddler


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PDKV Chironji Nut Grader cum Decorticator

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# PKV RESEARCH JOURNAL (ISSN 0378-813X)



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This publication is included in the abstracting and indexing coverage of Biosciences Information Service of Biological Abstracts and Field Crop Abstracts.

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**Vol. 45** **No. 1** **January, 2021**

PKV Res. J. Vol. 45(1), January, 2021

# Status and Strategies for Turmeric and Ginger Production in India

**Homey Cheriyan[1], J. S.Remya[2] and K. Manojkumar[3]**

Turmeric and Ginger, which belong to the family *Zingiberaceae*, are two important spice crops of India. Apart from the role they play as a foreign exchange earner, the domestic market for these crops is so strong, that the ups and downs in this sector affect a large section of the people. Both these crops are an inseparable part of the Indian cuisines used mostly as spice and also extensively used in the Indian Systems of Medicines for the medicinal value attributed to them.

## 1. Turmeric

Turmeric of commerce is the dried rhizome of the plant *Curcuma longa* L. In India, it has been used for centuries as a spice, food preservative, colouring agent, cosmetic as well as for its medicinal properties. The colouring principle of turmeric, 'curcumin' is the main component of this plant and is responsible for many medicinal properties. Of late, research is focused on turmeric's antioxidant, anti-carcinogenic, anti-inflammatory and antimicrobial properties, anti-aging, anti-alzheimer's in addition to its use in cardiovascular disease and gastrointestinal disorders. Recently, awareness of its unique medicinal properties is spreading fast. As a result, its demand especially for export is gaining momentum.

### 1.1 Indian Scenario

About 80% of the production of turmeric in the world is produced from India. During 2019-20, India produced 9.40 lakh tonnes of turmeric from an estimated area of 2.50 lakh ha. Turmeric can be grown in various climatic conditions, and also as an intercrop in coconut and arecanut plantations. It is mostly cultivated as a kharif crop. Telangana is the largest producer of turmeric in the country contributing about 35% of the total turmeric production in the country followed by Karnataka, Andhra Pradesh, Tamil Nadu, West Bengal, Madhya Pradesh, Orissa, Maharashtra, Mizoram, Assam, Gujarat, Sikkim etc. (Malhotra, 2016).

Though Kerala is not a significant producer of turmeric compared to other states, the turmeric produced here is having a premium position in the overseas market. Almost the entire quantity of turmeric produced in Kerala State is exported under the trade name "Alleppey Finger Turmeric (AFT)". Turmeric produced from different parts of the country varies in their quality attributes. Waigaon Turmeric and Sangli Turmeric from Maharashtra, Erode Turmeric from Tamil Nadu, Kandamal Turmeric from Odisha are having geographical indication. (Rao *et al*., 1975).

**Table 1. Statewise area, production and productivity of Turmeric in India 2019-20**

| State | Area ('000 ha) | Production ('000 tonnes) | Productivity (kg ha$^{-1}$) |
|---|---|---|---|
| Telangana | 48.00 | 312.00 | 6,500 |
| Karnataka | 26.905 | 150.00 | 5,575 |
| Tamil Nadu | 23.46 | 90.22 | 3,845 |
| Andhra Pradesh | 17.800 | 80.10 | 4,500 |
| Madhya Pradesh | 15.614 | 54.69 | 3,502 |
| West Bengal | 17.731 | 45.22 | 2,550 |
| Orissa | 27.866 | 43.61 | 1,565 |
| Maharashtra | 15.342 | 40.14 | 2,617 |
| Mizoram | 7.65 | 29.51 | 3,856 |
| Assam | 17.629 | 22.83 | 1,295 |
| Gujarat | 4.047 | 15.93 | 3,937 |
| Sikkim | 3.023 | 9.09 | 3,005 |
| Tripura | 1.71 | 7.72 | 4,529 |
| Kerala | 2.631 | 7.341 | 2,790 |
| Manipur | 2.151 | 5.51 | 2,562 |
| Arunachal Pradesh | 0.667 | 3.38 | 5,060 |
| Meghalaya | 2.67 | 3.31 | 1,240 |
| Punjab | 0.912 | 3.28 | 3,594 |
| Haryana | 1.083 | 2.93 | 2,701 |
| Bihar | 2.923 | 2.91 | 3 |

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| | | | |
|---|---|---|---|
| Uttarakhand | 1.386 | 2.46 | 1,773 |
| Chhattisgarh | 2.048 | 2.175 | 1,062 |
| Uttar Pradesh | 1.420 | 1.913 | 1,347 |
| Nagaland | 0.673 | 1.86 | 2,759 |
| Rajasthan | 0.22 | 0.43 | 1,950 |
| Andaman & Nicobar Islands | 0.115 | 0.231 | 2,009 |
| Himachal Pradesh | 0.269 | 0.17 | 617 |
| Jammu & Kashmir | 0.01 | 0.01 | 1,055 |
| Pondicherry | 0.002 | 0.01 | 2,500 |
| Total | 245.96 | 938.96 | 3,818 |

**production in terms of dry (processed)*

**1.2 Export and Import**

Indian turmeric has been known to the world since from ancient times and is considered as the best in the world because of its high curcumin content. India is the world's largest exporter of turmeric and Indian turmeric fetches premium price in the international market. About 16 to 17% of the turmeric produced in India is used for export purpose including turmeric powder, curcumin powder, oil and oleoresins. During 2018-19, India exported 1,29,100 tonnes of turmeric which consists of both dry whole and powder valued at Rs 1256.66 crores. Export of turmeric from the country increased substantially during the last ten years. The major export destinations of Indian turmeric are USA, Iran, UAE, Malaysia, Morocco, UK, Sri Lanka, Germany, Japan etc. Apart from this curcumin powder, turmeric oleoresin and turmeric oil are also being exported. (Ravindran *et al*., 2007).

In spite of being the largest producer of turmeric, India also imports turmeric for processing value added products, due to lack of aggregation of uniform grade/ variety of turmeric as per the requirement of the processing industry. Therefore, import of turmeric showed a substantial increase during the last ten years. Import of turmeric, which was 4450 tonnes valued at Rs 20.87 crores in 2009-10 had increased to 30,558 tonnes valued at Rs 299.47 crores in 2018-19. Turmeric is imported mainly for value addition and re-export. Turmeric is mainly imported from Vietnam, Indonesia, Myanmar, Ethiopia.

**Table 2. Export and Import of Turmeric**

| Year | Export | | Import | |
|---|---|---|---|---|
| | Quantity (tonnes) | Value (Rs in lakhs) | Quantity (tonnes) | Value (Rs in lakhs) |
| 2014-15 | 86,000 | 74,435 | 9300 | 7987 |
| 2015-16 | 88,500 | 92,165 | 15330 | 14635 |
| 2016-17 | 116,500 | 124,189 | 14150 | 16498 |
| 2017-18 | 107,300 | 103,568 | 17120 | 18434 |
| 2018-19 | 133,385 | 141,616 | 30578 | 29947 |

**1.3 Varieties**

The important varieties of turmeric are IISR Alleppey Supreme, IISR Pragati, IISR Kedaram, IISR Suvarna, Rajendra Sonia, IISR Suguna, IISR Sudharshana, IISR Prabha, IIST Prathibha, Kanthi, Sobha, Sona, Varna, PDKV Waigaon, Megha, Tekkurpetta, Sugandham, Rajendra Sonia, Roma etc.The major varieties of turmeric and their salient features are given below.

**1.4 Technologies to be Promoted**

***Protray Technique*** **:** Recently IISR, Calicut has developed a protray technology for raising healthy plantlets for direct planting in the field. For this, rhizomes are cut into single node/Eyes bits.. Nursery mixture containing either decomposed coir pith /Vermiculite mixed with biocontrol agents (*Trichoderma* and*P.flouresens*) is filled into the depression of protrays. Seed pieces are given seed treatment with Mancozeb or Metalxyl mancozeb for about thirty minutes. These treated seed pieces or rhizome pieces are sown in the cups of protrays with sufficient moisture in the depressions. These protrays are maintained in shade with a provision of sprinkler to ensure high humidity. Seed pieces start sprouting by 20-30 days. Sprouted seedlings of 30-45 days are transplanted into the previously formed beds or ridges. All other agronomic practices like fertilizer etc, are followed as usual. This method reduces the seed rate from 2 tones to 0.75tones and the crop remained uniform, healthy and productive and this technology however needs popularization.

**1.5 Production Constraints**

The problems confronted for increasing the production of turmeric are:

**Table 3. Turmeric varieties and their salient features**

| Variety | Fresh mean yield (t ha$^{-1}$) | Maturity (days) | Dry recovery (%) | Crucumin (%) | Oleoresin (%) | Essential oil (%) |
|---|---|---|---|---|---|---|
| Suvarna | 17.4 | 200 | 20.0 | 4.3 | 13.5 | 7.0 |
| Suguna | 29.3 | 190 | 12.0 | 7.3 | 13.5 | 6.0 |
| Sudarsana | 28.8 | 190 | 12.0 | 5.3 | 15.0 | 7.0 |
| IISR Prabha | 37.5 | 195 | 19.5 | 6.5 | 15.0 | 6.5 |
| IISR Pratibha | 39.1 | 188 | 18.5 | 6.2 | 16.2 | 6.2 |
| IISR Pragati | 38.0 | 180 | 18.0 | 5.0 | 12.1 | 5.2 |
| Alleppey Supreme | 35.4 | 210 | 19.3 | 6.0 | 16.0 | 4.0 |
| Kedaram | 34.5 | 210 | 18.9 | 5.5 | 13.6 | 3.0 |
| Co-1 | 30.0 | 285 | 19.5 | 3.2 | 6.7 | 3.2 |
| BSR-1 | 30.7 | 285 | 20.5 | 4.2 | 4.0 | 3.7 |
| BSR-2 | 32.5 | 245 | 20.0 | 3.8 | - | - |
| Krishna | 9.2 | 240 | 16.4 | 2.8 | 3.8 | 2.0 |
| Roma | 20.7 | 250 | 31.0 | 9.3 | 13.2 | 4.2 |
| Suroma | 20.0 | 255 | 26.0 | 9.3 | 13.2 | 4.2 |
| Ranga | 29.0 | 250 | 24.8 | 6.3 | 13.5 | 4.4 |
| Resmi | 31.1 | 240 | 23.0 | 6.4 | 13.4 | 4.4 |
| Rajendra Sonia | 42.0 | 225 | 18.0 | 8.4 | - | 5.0 |
| Megha | 23.0 | 310 | 16.4 | 6.8 | - | - |
| Kanthi | 37.7 | 240-270 | 20.2 | 7.2 | 8.3 | 5.2 |
| Sobha | 35.9 | 240-270 | 19.4 | 7.4 | 9.7 | 4.2 |
| Sona | 21.3 | 240-270 | 18.9 | 7.1 | 10.3 | 4.2 |
| Varna | 21.9 | 240-270 | 19.1 | 7.9 | 10.8 | 4.6 |
| Sugandham | 15.0 | 210 | 23.3 | 3.1 | 11.0 | 2.7 |

1. Adoption of traditional cultivation practices by majority of the farmers.
2. Non-availability of quality seed material of high yielding varieties with high curcumin content.
3. Lack of varietal purity
4. High cost of production
5. Wide fluctuations in prices of turmeric

**1.6 Strategies to Enhance the Production**

The following are the strategies being adopted to enhance the production and productivity of turmeric in the country.

1. Bring more area under high yielding varieties with high curcumin content.
2. Popularize high curcumin and low oil varieties in selected areas to establish turmeric export hubs
3. Encourage production of healthy seed rhizome in public and private domain.
4. Establishment of a seed chain system utilizing tissue culture technologies like micro rhizome production and protray method of nursery raising to produce disease free material at the same time maintain purity of varieties.
5. Popularize GAP with special emphasize on seed treatment with chemical and biocontrol agents to reduce incidence of disease.
6. Popularize effective seed storage methods.

7. Create awareness of varieties with high curcumin content.
8. Introduce mechanization to reduce cost and improve quality of turmeric production.
9. Popularize organic cultivation as there is ample market for it.
10. Coverage of more area under raised bed with micro irrigation.

**2. Ginger**

Ginger has been cultivated in India both for fresh vegetable and dried spice since time immemorial. Indian ginger has been acclaimed worldwide for its characteristic taste, flavour& texture. Ginger has always meant many things to different people; as a tastemaker, a flavourant, an appetizer and as a drug. Indian dry ginger is known in the world market as 'Cochin ginger' (NUGC) and 'Calicut ginger' (NUGK). India offers ginger in a variety of forms such as raw ginger, dry ginger, bleached dry ginger, ginger powder, ginger oil, ginger oleoresin, ginger candy, ginger beer, brined ginger, ginger wine, ginger squash, ginger flakes etc. With respect to industry usage as an end product, it is used in Food Industry, Pharmaceutical Industry, Cosmetic Industry and Others. The food industry currently represents the largest segment for processed ginger products owing to their usage in the preparation of numerous food products ranging from breads and other bakery products to smoothies and curries.

**2.1 World Scenario**

Ginger is extensively grown in India, China, Nigeria, Nepal, Indonesia, Thailand, Bangladesh, Cameroon, Japan, Philippines, Sri Lanka, Ethiopia, Jamaica etc. As per FAO estimate, total production of ginger in the world is 36.54 lakh tonnes from an estimated area of 3.66 lakh ha. India tops in both area and production of ginger with 45% in area and 48% in production.

World import of Ginger is growing at an annual average growth rate of 6%. It is estimated that the total world import (demand) of dry ginger during 2020 is 1,57,550 metric tons. Pakistan, Japan, USA, Bangladesh, UAE, Malaysia, Netherlands, India, Saudi Arabia, UK, Germany are the major ginger importing countries in the world.

**2.2 Indian Scenario**

In India, Ginger is grown in almost all the states, as it grows well in warm and humid climate. Presently the major ginger growing States in India are Madhya Pradesh, Karnataka, Assam, Orissa, Maharashtra, West Bengal, Meghalaya, Sikkim, Mizoram, Arunachal Pradesh, Kerala, Nagaland, Gujarat etc.

**Table 4. Ginger: Area, Production and Productivity, Statewise, 2019-20**

| State | Area ('000 ha) | Production ('000 tonnes) | Productivity (Kg ha$^{-1}$) |
|---|---|---|---|
| Madhya Pradesh | 25.402 | 410.95 | 16,178 |
| Karnataka | 21.663 | 278.00 | 12,833 |
| Assam | 19.351 | 183.16 | 9,465 |
| Orissa | 16.573 | 128.00 | 7,723 |
| Sikkim | 13.412 | 65.65 | 4,895 |
| West Bengal | 12.219 | 133.24 | 10,904 |
| Meghalaya | 9.963 | 66.29 | 6,653 |
| Maharashtra | 9.073 | 131.91 | 14,539 |
| Mizoram | 8.553 | 61.00 | 7,132 |
| Arunachal Pradesh | 5.479 | 39.11 | 7,139 |
| Gujarat | 4.853 | 107.17 | 22,082 |
| Nagaland | 4.770 | 35.773 | 7,500 |
| Kerala | 4.265 | 83.94 | 19,681 |
| Uttarakhand | 3.094 | 31.569 | 10,203 |
| Chhattisgarh | 2.600 | 12.639 | 4,861 |
| Manipur | 2.416 | 17.90 | 7,410 |
| Himachal Pradesh | 2.181 | 8.77 | 4,022 |
| Tripura | 1.924 | 16.25 | 8,443 |
| Telangana | 1.827 | 12.76 | 6,986 |
| Uttar Pradesh | 0.904 | 4.294 | 4,750 |
| Haryana | 0.395 | 3.73 | 9,441 |
| Bihar | 0.363 | 3.136 | 8,639 |
| Andhra Pradesh | 0.294 | 3.200 | 10,884 |
| Tamil Nadu | 0.167 | 2.80 | 16,772 |
| Andaman & Nicobar Islands | 0.164 | 1.89 | 11,512 |
| Rajasthan | 0.107 | 0.37 | 3,486 |
| Jammu & Kashmir | 0.027 | 0.05 | 1,852 |
| **Total** | **172.04** | **1,843.53** | **10,716** |

**Production in terms of fresh*

The ginger produced in Southern States like Kerala, Karnataka are mainly used for making dry ginger. Ginger produced in North-Eastern States like Assam, Meghalaya etc are mostly used as fresh ginger. The ginger produced in Assam, "Assam KarbiAnglong Ginger" – got geographic indication.

**2.3 Export and Import**

Export of ginger is low when compared to that of other major spices. However, Indian ginger fetches a premium price in the international market because of its superior quality. In 2018-19 export of ginger was estimated at 18150 tonnes valued at Rs 196.02 crores. Export of ginger has showed declining trend during the last five years.

Sizeable quantity of fresh ginger is imported into India and to some extent dried ginger and ginger powder. This is mainly for processing, value addition and re-export. The major imports are from Nepal, Myanmar, China, Nigeria etc. During 2018-19, quantity of 30085 tonnes of ginger valued at Rs 161.54 crores were imported into the country.

**Table 5. Export and import of Ginger in India**

| Year | Export | | Import | |
|---|---|---|---|---|
| | Quantity (tonnes) | Value (Rs in lakhs) | Quantity (tonnes) | Value (Rs in lakhs) |
| 2014-15 | 40,400 | 33,133 | 23,050 | 10,666 |
| 2015-16 | 24,800 | 27,596 | 26,610 | 10,116 |
| 2016-17 | 24,950 | 25,705 | 35,605 | 9,201 |
| 2017-18 | 22,605 | 21,607 | 34,300 | 10,060 |
| 2018-19 | 18,150 | 19,602 | 30,085 | 16,154 |

**2.4 Varieties**

Several cultivars of ginger are grown in different ginger growing areas in India and they are generally named after the localities where they are grown. Some of the prominent indigenous cultivars are Maran, Himachal, Nadia, Kuruppampadi, Ernad and Wayanad. The exotic cultivar 'Rio-de-Janeiro' have also become very popular among cultivators. The improved varieties of ginger and their salient features are given below.

**2.5 Constraints in Ginger Production**

Inadequate availability of quality planting material is identified as the most important factor that limits ginger cultivation and its productivity. The biggest constraint identified in ginger production is the prevalence of diseases like soft rot diseases (both fungal and bacterial), *Bellakettu*disease and pests like shoot borer, rhizome maggot etc. Soft rot of ginger is very rampant and is one reason due to which farmers hesitate to take up the cultivation in large scale. Soft rot disease pervades new areas through the use of infected planting materials. Hence production of disease free planting material becomes the most important aspect in ginger cultivation. The main problems in ginger seed rhizome production are:

**a) High Seed Rate**: In ginger the seed rate is very high, around 1500-2000 kg/ha. Hence large quantity of seed rhizomes is required to cater to the requirement.

**b) The Bulk to be Handled is Difficult**: The yield of seed rhizomes would be around 10-15 tonnes /ha *i.e.* one hectare of seed production will cater the seed requirement for only 10 ha of ginger cultivation. Due to its bulky nature, transportation of ginger seed rhizomes through large distances is not feasible.

**c) Storage and Viability**: Ginger buds lose their viability with time. Under proper storage condition it can be maintained only for a couple of months. After the harvest till the next crop, ginger seed required to be stored for 4-6 months for which proper storage structures need to be put in place. If not stored properly, the seeds take a heavy toll through loss due to disease / loss of viability etc.

**d) Prevalence of Diseases and Pests**: Disease like soft rot, bacterial soft rot, *bellakettu* and pests like shoot borer, rhizome maggot are a major constraint both in field and in storage. The disease causes such a havoc that farmers restrict ginger cultivation to small areas only. Even researchers hesitate to work on this crop because of the disease.

**e) Crop Rotation Practiced in Ginger**: Because of the disease threat and nutrient exhaustion, ginger crop is not repeated in a place where it was raised the previous year. Usually a gap of 3 to 4 years is given. Hence area for cultivation of ginger becomes a hindrance.

**f) Wide Price Fluctuation**: Due to the uncertainty of the extent of ginger cultivation, there is a wide fluctuation of

**Table 6. Released varieties of ginger and their salient features**

| Variety | Fresh mean yield (t ha$^{-1}$) | Maturity (days) | Dry recovery (%) | Crude fibre (%) | Oleoresin (%) | Essential oil (%) |
|---|---|---|---|---|---|---|
| IISR Varada | 22.6 | 200 | 20.7 | 4.5 | 6.7 | 1.8 |
| IISR Mahima | 23.2 | 200 | 23.0 | 3.3 | 4.5 | 1.7 |
| IISR Rejatha | 22.4 | 200 | 19.0 | 4.0 | 6.3 | 2.4 |
| Suprabha | 16.6 | 229 | 20.5 | 4.4 | 8.9 | 1.9 |
| Suruchi | 11.6 | 218 | 23.5 | 3.8 | 10.0 | 2.0 |
| Suravi | 17.5 | 225 | 23.5 | 4.0 | 10.2 | 2.1 |
| Subhada | 18.0 | 210 | 22.4 | 3.4 | 10.4 | 2.0 |
| Himagiri | 13.5 | 230 | 20.6 | 6.4 | 4.3 | 1.6 |
| Athira | 21.0 | 220-240 | 22.6 | 3.4 | 6.8 | 3.1 |
| Karthika | 19.0 | 220-240 | 21.6 | 3.7 | 7.2 | 3.2 |
| Aswathy | 23.0 | 220-240 | 19.7 | 3.5 | 7.5 | 3.3 |

ginger prices which is exploited by the traders.

### 2.6 National Consultative Meet on Planting Material Production of Ginger and Turmeric

The National Consultative Meet on Planting Material Production of Ginger and Turmeric organized by DASD on 25$^{th}$ August 2014 under the chairmanship of Horticulture Commissioner had recommended for establishment of a production system for ginger and turmeric that could ensure freedom from disease and maintain the purity in the planting material produced for distribution to farmers. Production of seed rhizomes in public domain such as State Departmental Farms, State Agricultural Universities, ICAR institutions accounts for less than 5% of the total requirement. The planting material required for cultivation of this crop is primarily met through farmer to farmer exchanges. The Meet recommended to resort to microrhizome production followed by multiplication of rhizome in soil less medium in protected structure before it is multiplied in field for distribution among farmers.

### Microrhizome Technology

The microrhizome technology in ginger can ensure the production of disease free planting materials in ginger. Here single bud is taken and cultured in appropriate medium in aseptic condition to produce multiple shoot. When sufficient multiple shoots are developed, these multiple shoots are then individually cultured in high sucrose medium to produce micro rhizomes. The micro rhizomes are then grown further to obtain mature seed rhizome which will be disease free.

### Protray Method of Nursery Raising

The concept of nursery raising is gained popularity in ginger with the introduction of protray method. Here the seed rhizomes are cut into small pieces with single bud sprouts (about 5g) and sown in pro trays to grow seedlings. After attaining the growth of one month, the seedlings are used for transplanting in the field. This technique has been standardized to produce good quality planting materials with reduced cost. The yield level of ginger transplants is on par with conventional planting system. The advantages of this technology are:

1) reduction of quantity of seed rhizome required (and eventually reduced cost on seeds)
2) planting materials produced are disease free.
3) uniform crop growth.

### 2.7. Strategies

Following strategies are being adopted to increase the production and productivity of ginger in the country.

- Increasing area coverage under high yielding varieties with high oil content.

* Creation of awareness on importance of disease free ginger seed rhizomes and implementation of GAPs to reduce incidence of diseases in the field.
* Establishment of seed production centres for the production of disease free seed rhizomes
* Utilizationof micro tuber production technology
* Multiplication of seed rhizome in soil less medium in poly houses.
* Popularizing nursery raising using single node protray method to reduce cost of cultivation and reducing incidence of disease.
* Adoption of IPM/INM
* Popularization of improved technologies through Frontline demonstration
* Mechanization for post-harvest processing for quality improvement

## CONCLUSION

Spices have been an integral part of traditional Indian cuisine, because of the peculiar flavour and accompanying medicinal properties. Of late, awareness of health and medicinal benefits of spices like turmeric and ginger is spreading fast. As a result, its demand is gaining momentum in both domestic and overseas markets. India produces around 28 lakh tonnes of turmeric and ginger annually, out of which 80% of the produce is used for domestic consumption. As a leading producer, consumer and exporter in turmeric and ginger, it is important that we improve our production practices so as to ensure the production and export of clean, safe and quality produce of these spices. Adoption of Good Agricultural Practices (GAP) on a regional basis, ensuring availability of healthy seed rhizomes of high yielding varieties through advanced propagation technologies and mechanization are the key strategies for improving quality and reducing cost of production.

There is a growing demand for turmeric with high curcumin content and ginger with high oil content which is not being met presently due to its unavailability. The exporters resort to import of these turmeric and ginger to meet their business requirement. Hence it is necessary that cultivation of turmeric varieties with high curcumin and ginger with high oil is popularized so as to meet the growing demand in India and abroad.

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Received on 15 February, 2021

PKV Res. J. Vol. 45(1), January, 2021

# Camel Milk and Value Added Camel Milk Dairy Product Entrepreneurship in India : Present Status, Future Prospects and Challenges

**S. D. Narnaware[1], Rajesh Kumar Sawal[2] and Artabandhu Sahoo[3]**

## ABSTRACT

Camel milk is a valuable food with a long history of its use for thousands of years in many cultures. The global camel dairy market is currently growing at moderate rate due to awareness among consumers regarding numerous health benefits of camel milk. Manufacturers of camel dairy products are also diversifying the range and flavours of products that can be made from camel's milk. The production of camel milk requires high investments and it has to compete with the well-established cattle's milk market, thus diverse product portfolio is important for the industry players. Popular products include fresh/ pasteurized milk, flavoured milk, cheese, paneer, ice-cream, yoghurt, milk powder, infant formulae, chocolate etc. Companies in India, such as Aadvik foods (India) and Amul have their own in-house dairy product production facility and are getting good response from Indian consumers. In view of above, designing and implementation of entrepreneurship development policy for encouraging camel milk entrepreneurship and its market at state, national and international level is essential.

Camel milk is a valuable food with a long history of its use for thousands of years in many cultures. It is considered a very healthy drink due to low fat and cholesterol content in comparison to cow or goat milk. It also contains three times more Vitamin C and ten times higher iron content than cow milk (Meena *et al*., 2014). The camel is an excellent source of milk under hot arid and desert conditions with scarcity of food and water. The global camel dairy market is currently growing at moderate rate due to awareness among consumers regarding numerous health benefits of camel milk. Increasing popularity of camel milk due to its easy-to-digest property among lactose-intolerant consumers is expected to have a positive impact on the camel milk dairy industry. Medical research has also suggested that camel milk created a positive impact on children with autism to live a better life (Shabo and Yagil, 2005). Camel milk helps improve systemic immunity and gastrointestinal health and beneficial in type 2 diabetes.

Driven by these nutrient rich features, camel dairy products have been slowly gaining popularity across the world. Manufacturers of camel dairy products are also diversifying the range and flavours of products that can be made from camel's milk. The production of camel milk requires high investments and it has to compete with the well-established cattle's milk market, thus diverse product portfolio is important for the industry players. Popular products include fresh/ pasteurized milk, flavoured milk, cheese, paneer, ice-cream, yoghurt, milk powder, infant formulae, chocolate etc. Companies in India, such as Aadvik foods (India) have their own in-house dairy product like powder, chocolate etc production facility. Similarly, the Gujarat Co-operative Milk Marketing Federation Limited (GCMMF) has launched Amul Camel Milk in Indian markets in 2019 which is getting good response from Indian consumers.

This article will provide a brief overview of the present scenario of production and market potential, commercial value and competitiveness,future prospects and challenges influencing the camel milk dairy market in India.

## MATERIAL AND METHODS

Both primary and secondary data were collected for this study. Primary data was collected from camel milk producers/entrepreneurs/consumers through direct/ indirect contact or on the basis of their portfolio study. Secondary data was collected from published works in research journals or websites etc. Secondary sources of data from organizations or individuals was compiled and used. The data were also collected from own source and from staff of ICAR-National Research Centre on Camel

ICAR- National Research Centre on Camel, Bikaner, Rajasthan 334001.

participating in the health and extension programmes at camel rearing villages. The study of camel rearers about problems faced in camel milk marketing, their socio-economic demography, problem in developing entrepreneurship model for camel milk entrepreneurs was studied. The business model spread was studied from online portfolio of enterprises and personal contacts.

## RESULTS AND DISCUSSION

### Background of camel farming system in India

In last five decades, camel population recorded a decreasing trend in the Asian region including India. This might be due to declining trend in the use of camel in agricultural and transport works and less demand of camel milk and other products. Presently India stands tenth in the world with 0.25 million camels (FAOSTAT, 2019; Livestock Census-2019). Being a desert state, Rajasthan has the highest number of camels in India. In Rajasthan, several hundred thousand families below the poverty line depend on camels for their living and socio-economic development. Some Raika families (in Mewar and Malva region) generate additional income by selling camel milk, alleviating the chronic milk shortages typical of many rural areas.

### Present scenario of production and market potential of camel milk and value added camel milk dairy products

Recently, a private venture in Rajasthan, Aadvik Foods from Bikaner, has entered the market by setting up a chilling and pasteurization plant for camel milk. They make camel milk powder (which sells for Rs 6,650 $kg^{-1}$) and other products. Another venture by the Urmul Trust is expected to start its chilling plant in Pokharan soon. According to Mr. Hanwant Singh Rathore of the Lokhit Pashu Palan Sansthan (LPPS), "Charisma camel dairy" sells a 100 litres a day and pay owners Rs 60 to 70 $l^{-1}$. The buyers are in Hyderabad and Karnataka and it costs Rs 400 a litre as milk has to be transported in frozen packed conditions in ice boxes. Locally, he sells camel milk for Rs 200 $l^{-1}$. In addition, Gujarat's cooperative giant 'Amul' have succeeded in increasing the shelf life of camel milk from five days to 180 days, which has opened up huge markets across India. Amul dairy process a few thousand litres a day and have been successful in building a collection and distribution chain. They offer owners Rs 50 $l^{-1}$ which has largely helped Gujarat check the decline in camel population.

As per population projections for India, the projected population of India in 2022 will be approximatey 140 Crore. India has an estimated 77 million people with diabetes, which makes it the second most affected in the world, after China (Kannan, 2019). According to the 2019 National Diabetes and Diabetic Retinopathy Survey report released by the Ministry of Health and Family Welfare, the prevalence was found to be 11.8 per cent in people over the age of 50 (Vashist, 2021). If this is assumed to be the potential market for camel milk consumption, then there will be huge requirement of camel milk in future. On the other hand, there will be huge gap of camel milk supply due to very low population of camels and female camels. The daily requirement is surely going to rise in future.

The ICAR- National Research Centre on Camel Bikaner is taking efforts for increasing awareness regarding health benefits of camel milk through its milk parlour, museum and awareness campaigns. The Centre also worked in collaboration with other organizations such as medical colleges and NGOs for exploring health benefits of camel milk for specific conditions like autism, diabetes, tuberculosis etc in the past and the research is still continuing for other health conditions (Agrawal *et al*., 2005). A few customers also believe in camel milk as a general health tonic that raises their immunity status.

### Commercial value and competitiveness of available camel milk and value added camel milk dairy products in India

The commercial value of available camel milk dairy products was assessed by literature and online search of portfolio of enterprises involved in camel milk business. There are presently atleast 10 private companies dealing with sale of camel milk products in amazon, flipkart or other e-commerce platforms. These are Aadvik Foods, Hye Foods, Amul, Nutra Vita, Porta Bites, Pankti Nutrition, New Food, DNS global foods, Food Fair Nutrition Products LLP and Deserts Food. In addition few non established entrepreneurs are also involved with little share on the basis of demand from other states. Among government organizations only ICAR- National Research Centre on Camel, Bikaner is working on camel milk product

development and its sale through milk parlor at the Centre for awareness and popularization.

Following are the major companies and organizations involved in camel milk entrepreneurship.

**1. Aadvik Foods**

They are India's first company to process, brand and market Camel milk and its products in India & abroad. This enterprise launched camel milk and milk products in 2014 and now has turnover of about 4.5 crores annually. Initially, this company started its journey with just one litre of camel milk and today, it is procuring around 10,000 litres a month, having sold over 2 lakh litres over the last three-and-half years. The company routes its product range via e-commerce platforms such as Amazon, eBay, Flipkart, Bigbasket, Shopclues, Snapdeal and Doodhwala extensively.They launched a distinctive range of Camel milk products such as handmade milk soaps infused with essential oils, flavored milk powders, beauty products and delicious chocolates. They collaborated with all leading e-commerce channels for taking orders and supplying home delivery of their products. Due to e-commerce platform they are now able to serve deliveries of camel milk and products world wide such as USA, Dubai and UAE etc. Their product profile includes: Frozen camel milk, Fresh camel milk, Raw camel milk powder (freeze dried), Camel milk Ghee, Camel milk powder (plain), Camel milk powder (flavoured), Camel milk chocolates, Camel milk skin care cream and Camel milk soap.


*Source: https://aadvikfoods.com/*

**2. Amul**

Amul is the oldest milk coooperative company in India and a very popular brand among common people. Amul launched selling of camel milk in 2020 and presently deals with camel milk products such as Pasteurized Camel milk, Camel milk Ice cream, Camel milk chocolate and Camel milk powder.


*Source: https://www.amul.com*

**3. Kumbhalgarh Camel Dairy at the LPPS Camel Conservation Centre, Rajasthan.**

LokhitPashu Palak Sansthan (LPPS) is an example of social enterprise model, a non-profit organization operating in Jaisalmer district of Rajasthan. LPPS set up its first dairy project near Jaisalmer in 2008, supplying camel milk locally, mostly for diabetes patients. They work with leading national and international camel dairy experts and local camel breeders and herders to ensure the production of safe and hygienic camel milk products. The LPPS supplies camel milk to Ahmedabad, Surat, Mumbai, Ludhiana, Bangalore, Nasik, Gurgram, Delhi etc.

**4. Other small scale enterprises**

In 2014, Mr. Naresh Ratika started with sale of 1 litre of camel milk and today, he has reached the volume of 125 litres of selling camel milk at Rs. 120/litre every day. He identified 148 households in the Jaipur area and started supplying fresh camel milk to them. His consumer base includes children suffering from autism, diabetic patients and health conscious class. He has home delivery concept for the households selling the camel milk at Rs. 120 per litre. He also supply chilled fresh camel milk at major cities of North India. He procures camel milk from the potential areas near to Jaipur in 60 km periphery. He formed a company-Sarika Raika Camel Milk Bhandar, Jaipur in 2014. Now, he is supplying camel milk to Surat, Raipur, Ghaziabad, Mumbai, Shri Ganganagar, Chandigarh, Ludhiana and Indore.



Similarly, Mr. Sumer Singh started collecting camel milk and selling it fresh at major locations of Jaisalmer and has now earning satisfactorily. He is planning to sale camel milk at tourist spots of Jaisalmer and hotels and restaurants. He and other people like him also formed an association for camel milk collection and distribution at Sanwata, Jaislamer.

**5. ICAR- National Research Centre on Camel Bikaner**

This central government organization sells camel milk and value added camel milk products through its milk parlour for popularization and awareness of camel milk among tourists and general public. Presently different camel milk products such as Camel milk coffee, Camel milk kulfi, flavoured Camel milk, Camel milk Peda, Camel milk Ice-cream, Camel milk Kheer, Camel milk Lassi, Camel milk tea and Turmeric Milk are available for sale. The sale records of camel milk products shows that there is significant increase in sale through its milk parlour which shows the popularity of camel milk among public.


**Various camel milk products developed by ICAR-NRCC**

***Factors and challenges influencing the camel milk dairy market in India***

Although there is a huge scope and future potential in camel milk and its value added products in India, however following are the major challenges for camel milk based enterprises:

**1. Unorganized sector**

The people involved in camel rearing are mostly poor and uneducated; hence it is difficult to motivate them for doing organized camel dairy farming. Moreover the camel population has decreasing trend in India and people

involved in camel husbandry are also leaving camel farming and going for other work. The population of camels is scattered in so many pockets that it will be difficult to do organized milk collection, distribution and sale.

**2. Unawareness regarding beneficial properties of camel milk**

Although awareness is increasing among public regarding health benefits of camel milk, however the number of people consuming camel milk is very low compare to cow or buffalo milk.

**3. Unavailability**

Due to rapid and sharp decline in camel population, the camel milk is not readily available to the consumers as cow or buffalo milk. Hence although people who are in need of camel milkthey cannot have it due to not availability at the major cities of India. Nevertheless camel milk powder is having potential to supply to major cities through transport on e-commerce platforms due toease in packaging and storage for longer periods.

**4. High price**

The camel milk is costly compare to cow and buffalo milk hence cannot be afforded by all. Camel milk prices differ widely due to scattered customer base and less number of entrepreneurs involved.

## CONCLUSION

In conclusion, awareness and utilization of camel milk as health adjuvant are gradually increasing as the camel milk has been found to have unique properties of its proteins, fatty acids, richer microminerals and vitamin C compared to milk of other animal species, such as bovine milk. Therefore there is a need to design and implement entrepreneurship development policy for encouraging camel milk entrepreneurship and its market at state, national and international level. The cooperative/social enterprise model is most feasible model for camel milk enterprise since it can bring in professionalism in camel breedingand also bring down the cost of selling the product in the market as collection, storage and marketing functions will be carried out by cooperatives.

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Received on 27 April, 2021

PKV Res. J. Vol. 45(1), January, 2021

# Efficacy of Powder and Liquid formulation of *Azospirillum* and Phosphorus Solubilizing Bacteria on *Kharif* Grain Sorghum

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## ABSTRACT

The three-year field study on *kharif* grain sorghum was conducted during 2017 to 2019 at Akola to assess the "Efficacy of mode of application of biofertilizers on kharif grain sorghum" consisting of *Azospirillum,* Phosphorus Solubilizing Bacteria (PSB) at two different rates (2 and 4 ml/kg seed) in comparison to their powder formulation (@ 50 g/ kg each) and untreated control. The three year pooled data revealed that, application of RDF + Seed treatment with liquid *Azospirillum* @ 2 ml + PSB @ 2 ml per kg seed recorded significantly maximum grain weight per panicle (48.83 g) and it was found at par with RDF + Seed treatment with liquid *Azospirillum* and PSB @ 4 and 2 ml and @ 4 and 4 ml per kg seed. The grain no. per panicle (2495) and weight of cob (267 g) found significantly maximum with RDF + Seed treat with liquid *Azospirillum* @ 2 ml + PSB @ 2 ml $kg^{-1}$ seed. The application of RDF + Seed treat2ment with liquid *Azospirillum* @ 2 ml + PSB @ 2 ml per kg seed recorded significantly highest grain (40.47q $ha^{-1}$) and fodder yield (122.89 q $ha^{-1}$) and it was found at par with RDF + Seed treatment with liquid *Azospirillum* and PSB @ 4 and 2 ml and @ 4 ml and 4 ml per kg seed. The Similar trend was noticed with respect to the gross monetary returns, net monetary returns and B: C Ratio. The pooled results revealed a significant impact of *Azospirillum* + PSB inoculation in both powder and liquid form on grain and stover yields of sorghum as compared to no biofertlizer control. Further liquid forms proved promising to powder form.

Sorghum (*Sorghum bicolor* L. Moench) is the most important rainfed crop of India as evident from the fact that only 9.9% of its total acreage was under irrigation in 2015. Sorghum is cultivated on 4.96 m ha acreage (2019-20). Its latest production is 3.76 m t grain (2019-20) and has an average productivity of 979 kg $ha^{-1}$. The share of *kharif* season sorghum is slightly lower (47.3%) than *rabi* season (52.7). Substantial improvements in productivity of this crop have been made (771 kg $ha^{-1}$ in 2000 to 979 kg $ha^{-1}$ 2018) through development of high yielding varieties and hybrids. However, the fertilizer use has not seen matching growth leading to several deficiencies in soil that gets manifested in poor growth, low productivity and inferior grain quality for human consumption. As per FAO report, fertilizer use in rain fed sorghum in 2003-04 was only 43.6 kg NPK that is far behind their uptake (Propheter and Staggenborg, 2010). Non conducive production environment (moisture stress), high and ever escalating prices discourage farmers from using adequate fertilizer inputs. Bio fertilizers have been identified as an alternative to chemical fertilizers to increase soil fertility and crop production in sustainable farming. Biggest challenge in the bio-fertilizer is the survival of organisms up to time of field application. In solid based organic fertilizers; there is only six months shelf life of microorganisms. Liquid bio-fertilizer technology is an alternative solution to carrier based solid bio-fertilizers. These liquid biofertilizers microbes shelf life is higher than carrier based bio-fertilizers without considerable loss in viable counts. Liquid formulation of bio-fertilizer plays vital role in helping to solve the increasing self life in microorganisms. In current study the liquid bio-fertilizer is best way of sustainable agriculture for crop production. In this context use of bio fertilizers assume prominence. Liquid based *Azospirillum* + *Bacillus* + *Pseudomonas* cultures developed from UAS, Dharwad were found quiet promising for maize crop (Geeta Goudar *et al*., 2017). Since long time carrier / powder based *Azospirillum* and phosphate Solubilizing bacteria (PSB) cultures are used in food grain crops like sorghum and were found to have less shelf life, contamination and poor field performance. Keeping this in view, studies were made for assessing their suitability and effectiveness in sorghum.

## MATERIAL AND METHODS

*Kharif* season field experimentation on grain sorghum were carried out to ascertain the impact of *Azospirillum* + Phosphorus Solubilizing Bacteria (PSB)

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seed treatment in liquid formulation compared with its powder formulation. Study was conducted for three seasons at Akola location during 2017-19. Six treatments formed by combination of 4 different doses (ml/kg seed) of liquid formulation of *Azospirillum* + PSB bio fertilizers seed treatment i.e. 2 ml + 2 ml; 2 ml + 4 ml; 4 ml + 2 ml and 4 ml + 4 ml along with seed treatment with powder form of *Azospirillum* + PSB (50 g + 50 g per kg seed) and without bio fertilizer treated as a control i.e. recommended package of practice (RPP) receiving recommended dose of fertilizers were evaluated in RBD with four replications. All bio fertilizer treatments are over and above RPP. The liquid bio-fertilizer was procured from the UAS, Dharwad. Sorghum genotype CSH-16 was sown on 1st July, 13rd July and 30th June respectively during 2017, 2018 and 2019. Sowing was done at 45 cm apart maintaining a plant to plant spacing of 15 cm and grown as rainfed crop with all recommended package of practices. Data on growth, yield attributes and yield were collected as per standard and uniform procedures and economics were worked out based on output of crops and input costs. Respective Carrier based biofertilizer @ 50 g $kg^{-1}$ was mixed with the seeds and kept in shade for 20 minutes and used for sowing, for application of liquid based formulation plastic bag of 21 x 10 cm size used for the seed treatment of approximately 5 kg seed and apply 2 ml and 4 ml per kg liquid biofertlizer for *Azospirillum* and PSB as per the treatments. The bag shaking for 2 to 4 minutes or more until seed is uniformly coated. The sorghum crop was fertilized with Nitrogen, Phosphorus and Potassium @ 80:40:40, kg $ha^{-1}$ through Urea, Single Super Phosphate and Murate of Potash respectively as basal dose based on treatments and biofertilizer applied as seed inoculation.

## RESULTS AND DISCUSSION

**Growth and Yield Contributing Characters:** The Pooled data pertaining to the growth and yield parameters showed that (Table 1), plant height (cm), grain weight per panicle (g), weight of cob (g), grain no. per panicle and length of panicle (cm) found significant differences in response to liquid biofertilizer seed treatment.

Among the two check treatments and four liquid biofertilizer treatments, the year wise and pooled data revealed that, application of RDF + Seed treatment with liquid *Azospirillum* @ 2 ml + PSB @ 2 ml $kg^{-1}$ seed was recorded significantly maximum plant height (cm) and panicle length (cm) and it was found at par with RDF + Seed treat with liquid *Azospirillum* @ 4ml + PSB @ 2 ml $kg^{-1}$ seed and RDF + Seed treat with liquid *Azospirillum* @ 4 ml + PSB @ 4 ml $kg^{-1}$ seed. During the 2019-20, Significantly maximum plant height (184 cm) and panicle length (31.58 cm) was recorded with RDF + Seed treat with liquid *Azospirillum* @ 4ml + PSB @ 4 ml $kg^{-1}$ seed and it was found at par with RDF + Seed treat with liquid *Azospirillum* @ 4 ml + PSB @ 2 ml $kg^{-1}$ seed, RDF + Seed treat with liquid *Azospirillum* @ 2 ml + PSB @ 4 ml $kg^{-1}$ seed and RDF + Seed treat with liquid *Azospirillum* @ 2 ml + PSB @ 2 ml $kg^{-1}$ seed. The data regarding days to 50 % flowering and 100 seed weight were found not significant. The data regarding harvest index were found not significant.

The pooled data revealed that, application of RDF + Seed treatment with liquid *Azospirillum* @ 2 ml + PSB @ 2 ml per kg seed recorded significantly maximum Grain Wt per panicle and it was found at par with RDF + Seed treatment with liquid *Azospirillum* and PSB @ 4 and 2 ml and @ 4 and 4 ml per kg seed. The grain number per panicle ( 2495 ) and weight of cob ( 267 g ) found significantly maximum with RDF + Seed treat with liquid *Azospirillum* @ 2 ml + PSB @ 2 ml $kg^{-1}$ seed. However weight of cob found significantly superior over all other treatments but grain no. per panicle was found at par with RDF+ Seed treatment with *Azospirillum* + PSB @ 2 and 4 ml and @ 4 and 2 ml per kg seed. This might be due to availability of nutrients from RDF and beneficial effects accrued due to *Azospirillum* and phosphate Solubilizing bacteria (PSB) inoculation which provides nitrogen and phosphorus to plant growth. It may also be due to production of amino acids, vitamins and growth promoting substances like indole acetic acid and gibberellic acid secreted by these introduced beneficial microorganisms which resulted in enhanced nutrient uptake, translocation and synthesis of photosynthate assimilates which resulted increased plant growth characters and in obtaining economically profitable yield (Singh *et al*. 2006 and Suke *et al*. 2011). Use of biofertilizers improves the growth characters and biological yield of wheat (Amit Kumar and Urmila, 2018). These are very useful because

bacteria fix their nitrogen in the soil that's the reason production is increased. So, the combined application or the single use of biofertilizer can considered as the beneficial for the growth and yield of wheat (Noreen and Noreen, 2013)

**Yield and Economics :** The grain yield, Fodder yield , Biomass yield and Harvest index obtained in response to powder formulatiom and liquid biofertilizer seed treatments is presented in Table no 02. The pooled data and results showed that, the liquid biofertilizer seed treatments were found superior over RDF alone. The grain yield differed signficantly in response to liquid biofertilizer seed treatment. The application of RDF + Seed treatment with liquid *Azospirillum* @ 2 ml + PSB @ 2 ml per kg seed recorded significantly highest grain yield (40.47q $ha^{-1}$ ) and it was found at par with RDF + Seed treatment with liquid *Azospirillum* and PSB @ 4 and 2 ml and @ 4 ml and 4 ml per kg seed. The pooleld data revealed that, fodder yield also differed signficantly in response to liquid biofertilizer seed treatment. The application of RDF + Seed treatment with liquid *Azospirillum* @ 2 ml + PSB @ 2 ml per kg seed recorded significantly highest fodder yield and it was found at par with RDF + Seed treatment with liquid *Azospirillum* and PSB @ 2 and 4 ml, @ 4 and 2 ml and @ 4 ml and 4 ml per kg seed.

Pooled data reveals a significant influence of sorghum seed treatment with powder form of Azo + PSB on stover yields. A grain yield of sorghum was enhanced by 1.73 q $ha^{-1}$ owing to use of powder form of *Azospirillum* + PSB. The magnitude of increase in stover yields of sorghum were six time that of grain yield and though the tendency of grain yield showed an increase, the increases are marginal (1.73 q $ha^{-1}$) and thus did not qualify for statistical significance. *Azospirillum* and PSB used in their liquid form have brought substantial and significant gains in grain and stover yields over its powder formulation. The seed treatment with 2 ml *Azospirillum* + 2 ml PSB produced 5.23 q $ha^{-1}$ (19.82) increase in grain (stover) yields. Further, stover yields of all four doses of liquid form of Azo. + PSB were at par with each other while grain yields of 4 ml Azo + 2 ml PSB and 4 ml *Azospirillum* + 4 ml PSB were at par. Current investigations superiority of liquid based formulation of Azo + PSB over its powder formulation were supported by findings of Sivasakthivelan and Stella (2012) who observed better growth and yield of sunflower seed treated with liquid

**Table 1: Growth and Yield Contributing Characters of Sorghum as influenced by powder and liquid biofertilizer (Pooled data-2017 to 2019)**

| Treatments | Plant height (cm) | Days to 50 % flowering | 100 seed weight (g) | Grain weight (g) | No. of grain Panicle$^{-1}$ | Cob Weight (g) | Panicle Length (cm) | Harvest Index (% ) |
|---|---|---|---|---|---|---|---|---|
| RDF alone | 173 | 64.63 | 2.52 | 40.61 | 1996 | 191 | 26.57 | 25.09 |
| RDF (Azo. plus PSB seed treat @ 50 g each per kg seed | 174 | 63.88 | 2.57 | 42.62 | 2160 | 208 | 29.29 | 24.16 |
| RDF + Seed treat with Azo.@ 2 ml + PSB @ 2 ml per kg seed | 184 | 64.58 | 2.58 | 48.83 | 2495 | 267 | 31.58 | 24.79 |
| RDF + Seed treat with Azo. @ 2 ml + PSB @ 4 ml per kg seed | 180 | 64.83 | 2.48 | 45.34 | 2408 | 221 | 28.41 | 23.67 |
| RDF + Seed treat with Azo. @ 4 ml + PSB @ 2 ml per kg seed | 180 | 64.67 | 2.49 | 46.96 | 2414 | 244 | 31.25 | 24.82 |
| RDF + Seed treat with Azo. @ 4 ml + PSB @ 4 ml per kg seed | 181 | 65.08 | 2.54 | 46.34 | 2353 | 237 | 30.99 | 24.42 |
| SE (m) ± | 1.69 | 0.49 | 0.072 | 0.86 | 34.09 | 7.18 | 0.67 | 0.56 |
| CD at 5 % | 5.09 | NS | NS | 2.59 | 102.67 | 21.62 | 2.00 | NS |

**Table 2 : Yield and Economics of Sorghum as Influenced by influenced by powder and liquid biofertilizer (Pooled data-2017 to 2019)**

| Treatments | Grain Yield (q ha$^{-1}$) | Fodder Yield(q ha$^{-1}$) | Biomass Yield ( q ha$^{-1}$) | GMR (Rs ha $^{-1}$) | NMR (Rs ha $^{-1}$) | B:C Ratio |
|---|---|---|---|---|---|---|
| RDF alone | 33.82 | 101.06 | 134.88 | 81084 | 56864 | 3.35 |
| RDF (Azo. plus PSB seed treat @ 50 g each per kg seed | 35.55 | 111.58 | 147.13 | 86306 | 62006 | 3.55 |
| RDF + Seed treat with Azo.@ 2 ml + PSB @ 2 ml per kg seed | 40.47 | 122.89 | 163.35 | 97416 | 73116 | 4.01 |
| RDF + Seed treat with Azo. @ 2 ml + PSB @ 4 ml per kg seed | 36.84 | 118.81 | 155.66 | 90080 | 65740 | 3.70 |
| RDF + Seed treat with Azo. @ 4 ml + PSB @ 2 ml per kg seed | 39.81 | 120.62 | 160.43 | 95776 | 71436 | 3.93 |
| RDF + Seed treat with Azo. @ 4 ml + PSB @ 4 ml per kg seed | 39.09 | 121.23 | 160.32 | 94602 | 70222 | 3.88 |
| SE (m) ± | 0.73 | 2.05 | 2.11 | 1343 | 1343 | 0.06 |
| CD at 5 % | 2.21 | 6.17 | 6.34 | 4045 | 4045 | 0.17 |

formulation of *Azospirillum lipoferum* (AUAz1) + *Bacillus megaterium* (AU Ba-1) + *Pseudomonas fluorescens* (AU Ps-1) than its carrier based and alginate bead formulations. Geeta Goudar *et al.* (2017) also reported superiority of liquid based formulations in maize. Biofertilizers play vital role to enhance the growth as well as the yield of crop plants. They involve in various biotic activities and sustainable for crop production (Ahemad *et al.,* 2011). Biofertilizers play an important role in the growth of plants as well as they bring down the cost of chemical fertilizers e.g phosphorous, nitrogen and potassium. Biofertilizers contains microscopic microorganisms which are used as fertilizers for the growth of plants *e.g Azospirillum sp.* and *Azotobacter sp*. (Ribaudo *et al.,* 2006). *Azotobacter* plays a very important role in the growth of plants especially it improves the yield of wheat. The yield of wheat increases when it was inoculated with yeast + *Azotobacter* with 20 m-3 fad (Ahmed *et.al.,* 2011)

The economics worked out from the emerged data is presented in Table 2. The economics analysis study of pooled data revealed that, significantly highest monetary advantage in terms of gross monetary returns (Rs. 97416 ha$^{-1}$) was found with the liquid biofertilizer seed treatment viz. application of RDF + Seed treatment with liquid *Azospirillum* @ 2 ml + PSB @ 2 ml per kg seed and closely followed by RDF + Seed treatment with liquid *Azospirillum* @ 4 ml + PSB @ 2 ml per kg seed and RDF + Seed treatment with liquid *Azospirillum* @ 4 ml + PSB @ 4 ml per kg seed. The Similar trend was noticed with respect to the net monetary returns and B:C Ratio. Net income from *kharif* sorghum varied significantly among biofertilizer treatments due to variations in grain and stover yields. Use of sorghum seed treated with powder form of Azo + PSB at Parbhani has brought significant improvement in net income (Rs. 5142) over its untreated control (Rs.56864). Liquid form of Azo + PSB (mean over all its doses) on an average has Rs. 8122 higher net income than their powder formulation (Rs.62006) and Rs. 13264 higher net returns over rdf alone (Rs. 56864). Use of liquid *Azospirillum* @ 2 ml + PSB @ 2 ml (Akola) registered the highest net incomes that were significantly higher than its powder form. Net incomes of *Azospirillum* 4 ml + PSB 2 ml and *Azospirillum* 4 ml + PSB 4 ml were at par with the best treatment.

## CONCLUSION

Based on three year study at Dr.PDKV, Akola , it is concluded that seed treatment with powder form *Azospirillum* + PSB (both @ 50 g each) was rewardive both from yield and economics point of view. Use of liquid form of *Azospirillum* + PSB proved promising to over

control and powder form of bio fertilizers. Seed treatment with liquid *Azospirillum* @ 2 ml + PSB @ 2 ml per kg seed along with RDF is recommended in *kharif* sorghum for obtaining higher grain yield, fodder yield and monetary return. Liquid bio-fertilizes is considered the best choice for traditional carrier-based biofertlizer in modern agriculture, which helps in achieving increased crop yields, soil health and sustainable global food production.

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Received on 20 March, 2021

PKV Res. J. Vol. 45(1), January, 2021

# Exploring Genetic Potential of Carom Seed (*Trachyspermum ammi* L.) Germplasm for Seed Yield in Akola Conditions

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## ABSTRACT

Carom seeds (*Trachyspermum ammi* L.) has long been used in traditional Indian cuisine and Ayurvedic medicine. Cultivation of carom seed or ajwain reported for brining profit to farmers as a basically a dryland crop which can be grown with very less amount of water and minimum inputs. Ajwain has wide scope for boosting socio-economic status of farmers of Vidharbha region having marginal land holdings and mostly depends on dryland farm practices.The selection or recommendation of any crop for a particular region depends primarily on its adaptation to the soil and climatic conditions and preferably on their having resistance for other biotic factors viz., pest and diseases. These aspects of adaptation moreover depend on genetic potential and its expression in context of particular environment.Therefore, an experiment was carried out for exploring the genetic potential of twenty-sixcultivars of ajwain in Randomized Block Design with three replications during Rabi 2020 at Chilli and Vegetable Research Unit(CVRU), Dr. PDKV, Akola. Investigation revealed the presence of wide range of variability for all the characters viz., number of seeds per umbel, number of umbels per plant, plant height at maturity, days to first flowering, days to 50 per cent flowering, days to maturity, number of seeds per umbellate, number of umbellate per umbel, seed yield per plant, number of primary branches per plant, diameter of main umbel, length of first internode and test weightamong the genotypes, which are amenable to improvement. Further, it significant seed yield potential was exhibited by genotypes viz., PDKV AJ 11, PDKV AJ 10 and PDKV AJ 16 indicating their fitness at the location and subsequently they may be used in future breeding program or may be tested on large area for suitability for cultivation in the Vidarbha region.


Carom Seed or Ajwain (*Trachyspermum ammi* L.) belongs to family Apiaceae is a native of Egypt and is a popular seed spice crop in India. It is an annual herbaceous plant bearing small egg shaped grayish brown fruits. Themajor Ajwainproducing countries are India, Persia, Iran, Egypt, Afghanistan, Pakistan and North Africa. In India its productionis concentrated mainly in Rajasthan, Gujarat, Andhra Pradesh, Madhya Pradesh, Bihar, Uttar Pradesh, TamilNadu and West Bengal. Ajwain is an annual herbaceous plant, which profusely branches, with feather like leaves, 2-3pinnately divided, segments linear. Flowers in terminal compound umbel, which on fertilization converts in the minute grayish white fruits which are ovoid in nature. The diploid chromosome number of ajwain is 2n=18. Theflowers are portentous and cross-pollination occurs through insects. Ajwain seed analysis has revealed it to contain fiber (11.9%), carbohydrates (38.6%), tannins, glycosides, moisture (8.9%), protein (15.4%), fat (18.1%), saponins, flavone and mineral matter (7.1%) containing calcium, phosphorous, iron and nicotinic acid. Ajwain fruits yield 2 to 4 per cent brownish essential oil, with thymol as the major constituent (35 to 60%) (Ishikawah, 2001).

The genetic variability and correlation study helps to determine the yield contributing characters on which the selection can bebased for genetic improvement in yield and thus helps in the selection ofelite genotypes. Heritability and genetic advance are important selection parameter. Heritability estimates along with genetic advance are more helpful in predicting the gain under selection. Therefore, the present investigation was planned to evaluatethe genetic potential in terms of magnitudes of variability for the yield and its contributing traits of available ajwain genotypes in Akola conditions.

## MATERIAL AND METHODS

Experimental material comprised of twenty six lines of ajwain.Out of which twenty-two genotypes were collected from Chilli and vegetable research unit, Dr.PDKV, Akola where the pedigree had been maintained. Four

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varieties *viz.*, AA-19-01, AA-2, PKV07andAA-93 were collectedfrom National Research Centre on Seed Spices (NRCSS), Tabji, Ajmer, Rajasthan. Keeping in-view the necessity for exploration of existing genetic variability present in the available genepool of ajwain, an experiment for morphological characterization was conducted in Ajwain (*Trachyspermum ammi* L.) emphasizing on exploration the nature and magnitude of variability for different characters using twenty-six genotypes during Rabi 2020-2021 at Chilli and Vegetable Research Unit Dr. PDKV, Akola.

The observations were recorded for the important thirteen characters studied viz., days to first flowering, days to 50 per cent flowering, days to maturity, plant height at maturity, number of primary branches per plant, length of first internode, number of umbels per plant, number of umbellate per umbel, number of seeds per umbel, number of seeds per umbellate, diameter of main umbel, test weight and seed yield per plant.

The mean value worked out from the observations recordedon five randomly selected plants for thirteen morphological characters used for statistical analysis. The following statistical parameters used for presentation of data on quantitative attributions. Statistical analysis was carriedout as per the standard methods / techniques. The mean values of all the characters of each genotype in each replication were used for analysis of variance. The significant differences for all the characters among thegenotypes was tested by 'F' test**.** The genetic parameters such as genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability and genetic advance for different characters was worked out for all the genotypes under study using standard procedures.

## RESULTS AND DISCUSSION

The results of analysis of variance for all thirteen characterstudied are presented in Table 1. The significance was tested by applying'F' test. The mean sum of squares, due to genotypes found to be highly significant for all the characters, indicating the presence of substantial genetic variability in the experimental material. The range of all thirteen morphological traits are given in Table 2, revealed the presence of wide ranges of variation were observed for all the thirteen characters amongtwenty six ajwain genotypes in present investigation. The variation was thehighest for number of seeds per umbel (147.50-424.98), number of umbelsper plant (30.24-119.24), plant height at maturity (75.57-118.33), days tofirst flowering (61.67-92.33), days to 50 per cent flowering (82.00-110.67), days to maturity (129.67-144.67), number of seeds per umbellate (11.33-22.28), seed yield per plant (3.02-8.29), number of umbellate per umbel(9.31-16.46), number of primary branches per plant (8.42-13.19), while itwas found in lower magnitude for length of first internode (1.77-3.38) and diameter of main umbel (3.03-4.23) and test weight (0.52-1.42).

The present study genetic parameter analysis revealed that the magnitude of phenotypic coefficient of variation were higher than the corresponding genotypic coefficient of variation for the characters *viz*., days to first flowering, days to50 per cent flowering, days to maturity, plant height at maturity, number ofprimary branches per plant, length of first internode, number of umbels perplant, number of umbellate per umbel, number of seeds per umbel, numberof seeds per umbellate, diameter of main umbel, test weight and seed yieldper plant. However, the differences were narrow which implied their relative resistance to environmental variation. It indicated that in present material,the genetic factors were predominantly responsible for expression of the character studied. Therefore, selection could be made effectively on thebasis of phenotypic performance. The higher magnitude of PCV than GCVwere also observed by Jyothi *et al*.(2017), Kumar *et al*. (2017) in fennel, Meena and Dhakar (2017), Yadav *et al.* (2017),Nagar *et al*. (2018), Yadav *et al*. (2018) and Singh *et al.* (2019)

The phenotypic coefficient of variation for the character studied ranged from 4.01 per cent to 33.05 per cent. The phenotypic coefficient of variation was the highest for characters *viz*. number of seeds umbel$^{-1}$ (33.05%), test weight (31.08 %), seed yield plant$^{-1}$ (29.86 %), number of umbels plant$^{-1}$ (27.58 %), length of first internode (22.08 %) and number of seeds umbellate$^{-1}$ (20.94 %). This finding is in close harmony with the results of for number of umbels per plant and seed yield per plant

**Table1.Analysis of variance forthe thirteen morphological characters**

| Source ofvariation | Df | Meansumofsquares | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Days to first flowering | Days to 50% flowering | Days to maturity | Plant height at maturity (cm) | Number of primary branches perplant | Length of first internode (cm) | Number of umbels plant$^{-1}$ |
| Replications | 2 | 0.66666 | 8.769 | 4.884 | 32.030 | 0.443 | 0.046 | 9.966 |
| Genotypes | 25 | 270.498** | 173.251** | 73.042** | 493.785** | 4.886** | 0.458** | 1617.919** |
| Error | 50 | 7.120 | 12.662 | 7.831 | 55.646 | 1.018 | 0.17 | 26.050 |

continued..... ,

| Source of variation | Df | Meansumofsquares | | | | | |
|---|---|---|---|---|---|---|---|
| | | Number of umbellate umbel$^{-1}$ | Number of seeds umbel$^{-1}$ | Number of seeds umbellate$^{-1}$ | Diameter of mainumbel (cm) | Test weight (g) | Seed yield plant$^{-1}$ (g) |
| Replications | 2 | 0.457 | 245.383 | 5.609 | 0.017 | 0.008 | 0.364 |
| Genotypes | 25 | 14.584** | 24008.738** | 32.532** | 0.505** | 0.175** | 7.125** |
| Error | 50 | 1.001 | 1114.286 | 3.492 | 0.081 | 0.001 | 0.151 |

*,**significant at 5% and 1% levelofsignificance respectively

**Table2.Mean performance of twentysix ajwain genotypes for thirteen morphological characters**

| S.N. | Genotypes | Days to first flowering | Days to 50% flowering | Days to maturity | Plant height at maturity (cm) | No. of primary branches plant$^{-1}$ | Length of first internode (cm) | No. of umbels plant$^{-1}$ | No. of umbellate umbel$^{-1}$ | No. of seeds umbel$^{-1}$ | No. of seeds umbellate$^{-1}$ | Diameter of main umbel (cm) | Test weight (g) | Seed yield plant$^{-1}$ (g) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | PDKVAJ 01 | 75.67 | 83.33 | 132.33 | 80.37 | 9.15 | 1.97 | 70.09 | 15.14 | 244.61 | 19.47 | 3.03 | 0.91 | 4.13 |
| 2 | PDKVAJ 02 | 80.00 | 90.00 | 131.67 | 90.73 | 10.85 | 2.57 | 53.19 | 11.73 | 338.67 | 20.61 | 3.27 | 1.02 | 4.17 |
| 3 | PDKVAJ 03 | 74.33 | 88.33 | 130.33 | 89.40 | 8.78 | 2.50 | 60.78 | 13.42 | 225.50 | 19.14 | 4.10 | 1.05 | 3.02 |
| 4 | PDKVAJ 04 | 91.67 | 91.33 | 131.67 | 88.40 | 9.99 | 1.97 | 62.66 | 15.93 | 424.96 | 19.77 | 3.17 | 0.56 | 6.78 |
| 5 | PDKVAJ 05 | 64.67 | 82.00 | 132.67 | 80.10 | 10.71 | 2.57 | 59.13 | 14.75 | 185.45 | 15.89 | 4.03 | 0.73 | 3.13 |
| 6 | PDKVAJ 06 | 77.33 | 92.00 | 144.67 | 80.80 | 10.94 | 2.07 | 101.67 | 14.59 | 227.62 | 18.48 | 4.00 | 0.56 | 6.87 |
| 7 | PDKVAJ 07 | 90.00 | 96.33 | 144.33 | 75.57 | 8.60 | 2.13 | 81.27 | 10.55 | 147.51 | 16.05 | 3.37 | 0.74 | 4.23 |
| 8 | PDKVAJ08 | 64.67 | 83.00 | 141.33 | 81.43 | 8.42 | 2.12 | 89.54 | 9.35 | 215.78 | 18.62 | 3.20 | 0.96 | 3.03 |
| 9 | PDKVAJ09 | 61.67 | 90.00 | 133.33 | 81.03 | 10.36 | 2.03 | 59.21 | 9.65 | 190.43 | 15.01 | 3.33 | 1.42 | 6.51 |
| 10 | PDKVAJ 10 | 71.67 | 92.33 | 135.67 | 86.77 | 8.89 | 2.27 | 114.47 | 11.50 | 405.07 | 21.85 | 3.50 | 1.06 | 8.16 |
| 11 | PDKVAJ11 | 91.67 | 107.33 | 132.67 | 103.67 | 9.54 | 2.53 | 79.23 | 13.69 | 194.05 | 12.79 | 3.10 | 1.26 | 8.29 |
| 12 | PDKVAJ 12 | 84.67 | 102.33 | 132.33 | 77.40 | 9.02 | 3.03 | 30.24 | 9.31 | 149.59 | 21.54 | 4.10 | 0.89 | 6.32 |
| 13 | PDKVAJ 13 | 78.67 | 93.67 | 132.33 | 83.93 | 9.13 | 2.37 | 71.67 | 14.17 | 394.98 | 14.75 | 4.00 | 1.03 | 4.63 |
| 14 | PDKVAJ 14 | 76.67 | 89.67 | 129.67 | 86.57 | 8.70 | 2.50 | 91.91 | 9.71 | 282.91 | 13.56 | 3.03 | 0.53 | 4.73 |
| 15 | PDKVAJ 15 | 85.00 | 98.67 | 135.33 | 94.27 | 11.60 | 2.60 | 101.51 | 13.43 | 388.49 | 11.54 | 3.07 | 0.54 | 5.63 |
| 16 | PDKVAJ 16 | 74.67 | 89.33 | 133.33 | 85.63 | 13.19 | 2.03 | 115.07 | 13.15 | 359.55 | 11.66 | 4.20 | 0.64 | 7.84 |

**Table 2 Continued…**

| S.N. | Genotypes | Days to first flowering | Days to 50% flowering | Days to maturity | Plant height at maturity (cm) | Number of primary branches plant$^{-1}$ | Length of first internode (cm) | No. of umbels plant$^{-1}$ | No. of umbellate umbel$^{-1}$ | No. of seeds umbel$^{-1}$ | No. of seeds umbellate$^{-1}$ | Diameter of main umbel (cm) | Test weight (g) | Seed yield plant$^{-1}$ (g) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 17 | PDKVAJ17 | 75.33 | 87.33 | 132.33 | 94.47 | 10.83 | 2.23 | 95.44 | 13.28 | 335.35 | 22.28 | 3.80 | 0.58 | 3.45 |
| 18 | PDKVAJ18 | 71.33 | 91.00 | 131.67 | 104.43 | 10.57 | 2.10 | 70.71 | 15.30 | 188.97 | 17.56 | 4.03 | 0.64 | 5.33 |
| 19 | PDKVAJ19 | 68.33 | 84.00 | 130.33 | 112.33 | 9.19 | 3.17 | 111.46 | 16.46 | 302.10 | 20.90 | 3.43 | 0.53 | 4.27 |
| 20 | PDKVAJ20 | 87.33 | 96.33 | 131.67 | 99.20 | 11.74 | 2.27 | 106.04 | 13.33 | 235.37 | 11.33 | 3.67 | 0.52 | 6.49 |
| 21 | PDKVAJ21 | 63.00 | 86.00 | 132.67 | 118.33 | 12.43 | 1.77 | 118.27 | 14.89 | 252.04 | 19.20 | 3.70 | 0.62 | 4.12 |
| 22 | PDKVAJ22 | 92.33 | 110.67 | 144.67 | 107.07 | 10.74 | 1.87 | 95.61 | 13.13 | 282.87 | 19.43 | 3.17 | 0.78 | 5.08 |
| 23 | AA-19-01 | 78.00 | 90.00 | 144.33 | 100.37 | 10.03 | 2.20 | 87.44 | 15.80 | 414.88 | 19.55 | 4.23 | 0.86 | 6.18 |
| 24 | AA-2 | 88.00 | 106.00 | 141.33 | 102.77 | 11.15 | 2.40 | 76.07 | 12.52 | 217.97 | 17.31 | 3.93 | 0.67 | 5.08 |
| 25 | AA-93 | 65.33 | 85.33 | 133.33 | 113.33 | 11.61 | 2.50 | 101.93 | 16.27 | 419.70 | 15.94 | 3.67 | 0.68 | 4.44 |
| 26 | PKV-07 | 71.33 | 88.67 | 135.67 | 115.50 | 11.06 | 3.38 | 119.24 | 15.12 | 331.88 | 16.25 | 3.93 | 0.68 | 5.10 |
| | Max | 92.33 | 110.67 | 144.67 | 118.33 | 13.19 | 3.38 | 119.24 | 16.45 | 424.96 | 22.28 | 4.23 | 1.42 | 8.29 |
| | Min | 61.67 | 82.00 | 129.67 | 75.57 | 8.42 | 1.77 | 30.24 | 9.31 | 147.50 | 11.33 | 3.03 | 0.52 | 3.02 |
| | Mean | 77.05 | 92.11 | 135.46 | 93.61 | 10.27 | 2.35 | 85.53 | 13.31 | 282.93 | 17.32 | 3.61 | 0.79 | 5.26 |
| | S.E.(m)± | 1.54 | 2.05 | 1.61 | 4.30 | 0.58 | 0.24 | 2.94 | 0.57 | 19.27 | 1.07 | 0.16 | 0.02 | 0.22 |
| | C.D.5% | 4.37 | 5.83 | 4.58 | 12.23 | 1.65 | 0.68 | 8.37 | 1.64 | 54.74 | 3.06 | 0.46 | 0.07 | 0.63 |

andGhanshyam *et al*.(2014) for length of first internode. However, it was exhibited low for character days to maturity(4.01 %). Similar finding regarding PCV for days to maturity was also reported by Dhakad *et al*. (2017), Subramaniyan *et al*. (2018) and Rawat *et al.* (2020).

The genotypic coefficient of variation varied from 3.44 per cent to 30.87 per cent (Table 3). High genotypic coefficient of variation was noted for number of seeds per umbel (30.87 %), test weight (30.59 %), seed yield plant$^{-1}$ (28.93 %), number of umbels plant$^{-1}$ (26.93 %), number of seeds umbellate$^{-1}$ (17.95 %) and number of umbellate umbel$^{-1}$ (15.95 %) and length of first internode (13.08 %). The findings are in close harmony with Rawat *et al.* (2020) for number of umbels plant$^{-1}$ and seed yield plant$^{-1}$ and Rawat *et al.* (2020) for length of first internode. Days to maturity (3.44 %) and days to 50 per cent (7.94 %) showed the lower values of genotypic coefficient of variation, which resembles to the findings of Dhakad *et al*. (2017), and Subramaniyan *et al*. (2018) and Rawat *et al.* (2020) While it was recorded moderate for plant height at maturity, days to first flowering, number of primary branches plant$^{-1}$.

Over all coefficient of variation studies revealed the narrowrange between phenotypic coefficient of variation and genotypic coefficient of variation, indicating less influence of environmental factor on the expression of characters seed yield plant$^{-1}$, number of umbels plant$^{-1}$, test weight, number of seeds umbel$^{-1}$, length of first internodeand number of seeds umbellate$^{-1}$. Thus, these characters are confined to genetic factors. Therefore, selection based on phenotypic expression would be prove useful for obtaining the promising results.

The results indicated that the heritability estimates were very high for test weight, number of umbels plant$^{-1}$, seed yield plant$^{-1}$, days to first flowering, number of seeds umbel$^{-1}$, number of umbellate umbel$^{-1}$ and days to 50 per cent flowering. (Table 3). These results are in close proximate to that of Ghanshyam *et al*. (2014) for test weight, Meena *et al.* (2014) for number of umbels per plant, number of seeds per umbel, testweight and seed yield perplant, Dhakad *et al*. (2017) for days to first flowering and number of seeds umbel$^{-1}$ and Subramaniyan *et al*. (2018) and Rawat *et al.*(2020) seed yield plant$^{-1}$. Heritability estimates were recorded high for the traits viz., number of umbellate umbel$^{-1}$, days to 50 per cent flowering and days to maturity. The results were in close proximate to that of Ghanshyam *et al*.(2014) for days to 50 per cent flowering, Dhakad *et al*. (2017) number of umbellate umbel$^{-1}$ and Subramaniyan *et al*. (2018) for days to 50 per cent flowering and number of umbellate umbel$^{-1}$ and Rawat *et al.* (2020) for number of umbellate umbel$^{-1}$,daysto 50 percent flowering. The estimate of heritability were low for length of first internode which indicates that the character is rather more influenced by environment and may not respond much to selection. Whereas, character number of primary branches and diameter of main umbel exhibit moderate value of heritability, which is similar to the result reported by Ghanshyam *et al*. (2014), Meena *et al.* (2014) for number of primary branches plant$^{-1}$, Rawat *et al.* (2020) for diameter of main umbel.

The magnitude of genetic advance was ranged from 0.37 to 168.10 (Table 3). The value of genetic advance was recorded significantly highest for character number of seeds umbel$^{-1}$ (168.10) followed by number of umbels plant$^{-1}$ (46.32), days to first flowering (29.42) and plant height at maturity (21.18). Moderate values of genetic advance were recorded for days to 50 per cent flowering (19.16) and days to maturity (8.23). Whereas lower values of genetic advance were recorded for characters number of seeds umbellate$^{-1}$ (5.49), number of umbellate umbel$^{-1}$ (3.96), seed yield plant$^{-1}$ (3.04), number of primary branches plant (1.74), diameter of main umbel (0.61), test weight (0.49) and length of first internode (0.37). Results are in close proximate to that of Sharma *et al.* (2015), Dhakad *et al*. (2017) and Rawat *et al.* (2020). Heritability however, indicates only the effectiveness with which selection of genotype can be done, based on phenotypic performance, but fails to indicate the genetic progress. Heritability estimates along with genetic gain are more effective and reliable in predicting the improvement through selection. Estimates of genetic advance helps to predict the extent of improvement that can be achieved for improving the different characters. Genetic advance as percentage of mean ranged between 6.07 per cent to 62.02 per cent. The highest estimate of genetic advance as percentage of mean was recorded for test weight, number of seeds umbel$^{-1}$, seed yield plant$^{-1}$, number of umbel plant$^{-1}$, number of seed

**Table3: Estimates of genetic parameters studied for thirteen morphological characters in Ajwain**

| S.N. | Characters | Range | Mean | GCV (%) | PCV(%) | Heritability $h^2$ (%) | GA | GAM(%) |
|---|---|---|---|---|---|---|---|---|
| 1. | Daysto first Flowering | 61.67-92.33 | 77.05 | 12.16 | 12.64 | 92.50 | 29.42 | 24.09 |
| 2. | Daysto50% flowering | 82.00-110.66 | 92.12 | 7.94 | 8.83 | 80.87 | 19.16 | 14.71 |
| 3. | Days to maturity | 129.67-144.67 | 135.46 | 3.44 | 4.01 | 73.51 | 8.23 | 6.07 |
| 4. | Plantheightat maturity (cm) | 75.57-118.33 | 93.61 | 12.90 | 15.17 | 72.41 | 21.18 | 22.63 |
| 5. | No.ofprimary branchesper plant | 8.41-13.19 | 10.27 | 11.04 | 14.77 | 55.86 | 1.74 | 17.00 |
| 6. | Lengthoffirst internode(cm) | 1.77-3.38 | 2.35 | 13.08 | 22.08 | 35.08 | 0.37 | 15.96 |
| 7. | No.ofumbelsper plant | 30.23-119.24 | 85.53 | 26.93 | 27.58 | 95.32 | 46.32 | 54.16 |
| 8. | No.ofumbellate perumbel | 9.30-16.45 | 13.31 | 15.98 | 17.66 | 81.88 | 3.96 | 29.79 |
| 9. | No.ofseedsper umbel | 147.50-424.96 | 282.93 | 30.87 | 33.05 | 87.26 | 168.10 | 59.41 |
| 10. | No.ofseedsper umbellate | 11.33-22.28 | 17.32 | 17.95 | 20.94 | 73.49 | 5.49 | 31.71 |
| 11. | Diameterofmain umbel(cm) | 3.03-4.23 | 3.61 | 10.39 | 13.05 | 63.48 | 0.61 | 17.06 |
| 12. | Testweight(g) | 0.52-1.42 | 0.78 | 30.59 | 31.08 | 96.86 | 0.49 | 62.02 |
| 13. | Seed yieldperplant (g) | 3.02-8.29 | 5.26 | 28.93 | 29.86 | 93.88 | 3.04 | 57.75 |

umbellate$^{-1}$, number of umbels plant$^{-1}$, number of seeds umbellate$^{-1}$, number of umbellate umbel$^{-1}$, days to first flowering, plant height atmaturity, diameter of main umbel, number of primary branches plant$^{-1}$. These are similar to the findings of Dhakad *et al*. (2017), Jyothi *et al.* (2017) and Rawat *et al.*(2020).

## CONCLUSION

Further it is concluded that the genotypes viz., PDKV AJ 11, PDKV AJ 10, PDKV AJ 16, PDKV AJ 06, PDKV AJ 04, PDKV AJ 09, PDKV AJ 20, PDKV AJ 12, AA-19-01, PDKV AJ 18, PKV-07AA-2 and PDKV AJ 22 found high potential for seed yield, whereas PDKV AJ 14, PDKV AJ 19, PDKV AJ 02, PDKV AJ 04, PDKV AJ 18, PDKV AJ 20 were the early maturing genotypes, which can be exploited for further breeding programme and need to be tested on large area.

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Received on 2 April, 2021

PKV Res. J. Vol. 45(1), January, 2021

# Genetic Variability Studies in Sunflower Inbred Lines

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## ABSTRACT

The experiment was conducted at Oilseeds Research Centre, Dr. PDKV, Akola during Kharif 2020-2021, to study the Genetic Variability studies in Sunflower Inbred Lines. The experiment consisted of 24 sunflower inbred lines were evaluated with three checks (DRSF 108, DRSF 113 and PhuleBhaskar) respectively and was laid out in Randomized Block Design. Among inbred lines mean seed yield ranges from 6-42 g plant-$^{1}$, however EC 601635 (42 g plant-$^{1}$), GMU 770 (41 g plant-$^{1}$), GMU 494 (38 g plant-$^{1}$) and GMU 249 (35 g plant-$^{1}$) recorded significantly superior and highest seed yield over the three checks PhuleBhaskar (28 g plant-$^{1}$), DRSF 113 (27 g plant-$^{1}$) and DRSF 108 (25 g plant-$^{1}$) respectively. Phenotypic coefficients of variability ranged from 4.78 to 43.56 %, and the highest PCV was noticed for seed yield per plant and the lowest for Days to maturity. The highest genotypic coefficient of variability was recorded for seed yield per plant (42.99), whereas the lowest GCV was recorded for Days to maturity (4.34). Broad-sense heritability estimates were maximum for plant height (98.5), whereas they were moderate for 100 seed weight (49.5) Genetic advance as per cent of mean (GAM) was highest for seed yield per plant (87.41%) followed by plant height (39.7%), and the other traits showed a moderate-to-low genetic advance.

Sunflower (*Helianthus annuus L.*) is an important oilseed crop, which belongs to the genus 'Helianthus' of the family Asteraceae. It is widely adopted and accepted for its high quality and nutritional edible oil. Due to its high economic importance, the developments of effective hybrids are required with superior yield and quality traits. According to Oilseeds Scenario (2019), IIOR, Hyderabad sunflower contributed area (27.37 m ha) and production (56.07 m.t.) of oilseeds in the world and India placed 17$^{th}$ position in area and 21$^{st}$ position in production respectively. In India sunflower occupies 224.36 thousands ha area, 229.thousandstonnes production and 1023 kg ha-$^{1}$ productivity. Maharashtra occupies 266 thousands ha area under sunflower having 141 thousandstonnes production and 532 kg ha-$^{1}$ productivity (Anonymous, 2022.)

Existence of ample amount of genetic variability is pre requisite before embarking any breeding programme. Information of variability is useful to formulate selection criteria for improvement of seed yield and its component traits. Hence, variability present in a gene pool of a crop species is important to plant breeder for breeding programme.Classification of germplasm based on agronomic characters plays an important role in plant breeding to select valuable genetic resources to be utilized later in different breeding programmes.

The development of an effective plant breeding program is dependent upon the existence of genetic variability. Hence, an insight into the magnitude of variability present in a cross combinations is an indirect indication of genetic variability present in crop species. The coefficients of variation expressed at phenotypic and genotypic levels are used to compare the variability observed among different characters. A wide range of variation has been reported for seed yield, seed number and other important components of yield (Virupakshappa and Sindagi, 1988). The heritability estimates aid in determining the relative amount of heritable portion in variation and thus help plant breeder in selecting the elite inbreds from a diverse population. Heritability estimates along with genetic advance are normally more helpful in predicting the gain under selection than heritability estimates alone. The success of any breeding programme depends upon the extent of genetic variability in base population and it is essential to subject a population for selection for achieve improvement in a particular trait.

Therefore the present study was undertaken to study the genetic variability, heritability and genetic advance in 27 inbred lines.

## MATERIAL AND METHODS

The experiment consisted of 24 sunflower inbred

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**Table 1: Mean table of seed yield and related characters of 27 sunflower Inbred lines**

| S. N. | Genotype | Seed yield g plant$^{-1}$ | Days to 50% flowering | Days to maturity | Plant height (cm) | Head diameter (cm) | 100 seed wt (g) |
|---|---|---|---|---|---|---|---|
| 1 | TSG 17 | 6 | 55 | 80 | 124.4 | 13.7 | 3.8 |
| 2 | TSG 197 | 8 | 46 | 74 | 84.8 | 12.3 | 4.2 |
| 3 | TSG 207 | 9 | 50 | 78 | 78.0 | 10.9 | 5.1 |
| 4 | TSG 292 | 9 | 53 | 81 | 84.9 | 11.2 | 5.0 |
| 5 | TSG 331 | 11 | 54 | 80 | 79.8 | 9.8 | 5.8 |
| 6 | TSG 332 | 13 | 56 | 81 | 82.9 | 9.9 | 4.6 |
| 7 | HAR 9 | 15 | 56 | 82 | 102.9 | 10.7 | 4.3 |
| 8 | GMU 224 | 29 | 53 | 81 | 102.1 | 11.7 | 5.7 |
| 9 | GMU 249 | 35 | 57 | 86 | 98.3 | 13.8 | 5.5 |
| 10 | GMU 279 | 20 | 57 | 85 | 104.3 | 12.9 | 5.0 |
| 11 | GMU 357 | 21 | 57 | 83 | 108.0 | 11.1 | 5.3 |
| 12 | GMU 462 | 19 | 53 | 79 | 126.3 | 12.1 | 4.8 |
| 13 | GMU 494 | 38 | 54 | 78 | 97.5 | 10.2 | 5.2 |
| 14 | GMU 606 | 30 | 56 | 83 | 102.5 | 11.8 | 5.4 |
| 15 | GMU 616 | 28 | 56 | 83 | 109.4 | 11.9 | 5.9 |
| 16 | GMU 633 | 27 | 57 | 84 | 93.0 | 10.0 | 4.8 |
| 17 | GMU 638 | 26 | 53 | 79 | 99.2 | 10.0 | 4.6 |
| 18 | GMU 763 | 22 | 54 | 81 | 111.5 | 12.3 | 4.5 |
| 19 | GMU 770 | 41 | 53 | 82 | 132.9 | 13.9 | 4.2 |
| 20 | GMU 852 | 29 | 54 | 80 | 137.0 | 14.6 | 3.5 |
| 21 | GMU 934 | 30 | 53 | 82 | 142.2 | 15.5 | 3.8 |
| 22 | EC 601635 | 42 | 54 | 81 | 109.6 | 13.8 | 5.0 |
| 23 | $GP_6$ 1470 | 23 | 55 | 82 | 104.1 | 14.4 | 4.1 |
| 24 | $GP_6$ 303 | 20 | 55 | 84 | 112.4 | 14.2 | 4.5 |
| 25 | DRSF 108 (C) | 25 | 61 | 89 | 146.8 | 14.6 | 5.5 |
| 26 | DRSF 113 (C) | 27 | 60 | 91 | 141.5 | 15.7 | 6.0 |
| 27 | PhuleBhaskar (C) | 28 | 59 | 89 | 154.6 | 15.9 | 5.8 |
| | SE ± | 1.15 | | | | | |
| | CD at 5% | 3.34 | | | | | |
| | CV % | 7.02 | | | | | |

**Table2 : Genetic variability, genetic parameters, heritability and genetic advance in percent of mean for six quantitative traits in 27 sunflower inbred lines**

| SN | Characters | Mean sum of squares | σ2 g | σ2 p | Coefficient of variation | | | GA as % of mean |
|---|---|---|---|---|---|---|---|---|
| | | | | | GCV | PCV | h $^2$(b. s.) | |
| 1 | Seed Yield g plant-$^1$ | 200.31 | 98.84 | 101.47 | 42.99 | 43.56 | 97.40 | 87.41 |
| 2 | Seed Yield kgha-$^1$ | 18.23 | 8.71 | 9.51 | 5.40 | 5.65 | 91.60 | 10.66 |
| 3 | Days to Maturity | 27.96 | 12.61 | 15.34 | 4.34 | 4.78 | 82.20 | 8.10 |
| 4 | Plant Height cm | 922.40 | 457.77 | 464.63 | 19.44 | 19.59 | 98.50 | 39.76 |
| 5 | Head Diameter | 7.29 | 3.56 | 3.732 | 15.07 | 15.42 | 95.60 | 30.36 |
| 6 | 100-Seed Wt.(g) | 0.97 | 0.32 | 0.65 | 11.65 | 16.55 | 49.50 | 16.89 |

σ2g – Genotypic variance, σ2p-Phenotypic variance, GCV –Genotypic Coefficient of variation, PCV- Phenotypic Coefficient of variation,$h^2$(b. s.)-Heretability in broad sense, GA-Genetic advance.

lines were evaluated with three checks (DRSF 108, DRSF 113 and Phule Bhaskar) respectively and was laid out in Randomized Block Design. In this study illustrated that, the existence of wide ranges of variations for most of the characters among the sunflower inbred lines, Diversity among morphological traits can influence on heterosis and be reliable marker for prediction hybrid potential. The genus sunflower has a very high variability, in wild ecotypes as well in breeding genotypes. Sunflower genotypes differ in plant architecture, types of branching, flower color and morphology, number and size of heads, seed size and color and many other traits .At maturity five plants from each accession were selected randomly for recording of data on yield and its related characters viz. days to 50% flowering, duration of reproductive phase (days), days to maturity, plant height (cm), head diameter (cm), seed yield (g) and100-seed weight (g).

## RESULTS AND DISCUSSION

Among inbred lines (Table 1) mean seed yield ranges from 6-42 g plant$^{-1}$, however EC 601635 (42 g plant$^{-1}$), GMU 770 (41 g plant$^{-1}$), GMU 494 (38 g plant$^{-1}$) and GMU 249 (35 g plant$^{-1}$) recorded significantly superior and highest seed yield over the three checks PhuleBhaskar (28 g plant-$^{1}$), DRSF 113 (27 g plant$^{-1}$) and DRSF 108 (25 g plant-$^{1}$) respectively. Days to 50% flowering mean ranges from 46-60 days and mean range of days to maturity ranges from 74-91 days, however TSG 197 recorded early days to 50 per cent flowering (46 DAS) and early maturity (74 DAS). Plant height mean ranges from 78.0 cm (TSG 207) - 154.6 cm (check Phule Bhaskar). Head diameter mean ranges from 9.8 cm (TSG 331) -15.9 cm (check Phule Bhaskar). 100 seed weight mean ranges from 3.5 g (GMU 852) - 6.0 g (DRSF 113).

The success of any breeding programme depends upon the extent of genetic variability in base population and it is essential to subject a population for selection for achieve improvement in a particular trait. The mean squares from analysis of variance for different characters were presented in the Table 2. Analysis of variation indicated that the mean squares of the genotypes were highly significant for all the characters taken under study. The range of variation, as well as genotypic and phenotypic coefficient of variations were high for seed yield per plant, plant height and test weight indicating the scope of improvement through simple selection procedure for obtaining high yield.

The magnitude of PCV values for all the traits was marginally higher than the corresponding GCV values. Phenotypic coefficients of variability ranged from 4.78 to 43.56 %, and the highest PCV was noticed for seed yield per plant and the lowest for Days to maturity. The highest genotypic coefficient of variability was recorded for seed yield per plant (42.99), whereas the lowest GCV was recorded for Days to maturity (4.34). Broad-sense heritability estimates were maximum for plant height (98.5), whereas they were moderate for 100 seed weight (49.5) Genetic advance as per cent of mean (GAM) was highest for seed yield per plant (87.41%) followed by plant height (39.7%), and the other traits showed a moderate-to-low genetic advance.The GCV and PCV were high for seed yield, which indicated the presence of additive genes for this character (Patil *et al.,* 1996, Sujatha *et al.,* 2002 and Virupakshappa and Sindagi, 1987). The genotypic coefficient of variation is not always true to reflect the amount of actual variation which is heritable.

The heritable variation cannot be estimated through genetic coefficient of variation (Burton, 1952).Also the genotypic coefficient of variation along with heritability would give the reliable information on the magnitude of genetic advance to be expected from selection. The heritability in broad sense is described as the ratio of genotypic variance to the total variance in the non-segregating populations (Hanson *et al.,*1956). Further, it indicates whether there is sufficient genetic variation present in a population which will respond to selection pressure (Milatovic *et al.,*2010) Selection of the genotype based on specific character with high broad-sense heritability will lead to faster and increased gains in the offspring than selecting for specific character with low heritability (Browning *et al.,* 1994).

Broad-sense heritability estimate was maximum for plant height (98.5), while that for seed yield g per plant (97.4) and head diameter (95.6). Hence, higher heritability estimates for these traits indicated that environmental factors did not greatly affect phenotypic variation of these characters.

The present study exhibited very high differences among the genotypes for seed yield almost all yield component characters which may favour the selection and itsfurther utilization in recombination breeding programmes. While selecting appropriate sunflower germplasm, the breeder looks for genetically diverse and superior genotypes which could be utilized in population and heterosis breeding. The genetically diverse sunflower germplasm identified could be utilized in development of diverse inbreds which may be utilized in heterosis breeding. Promising trait specific superior sunflower germplasm accessions identified will serve as donors for the development of trait specific heterotic gene pools which can be further exploited in sunflower improvement.

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Received on 23 May, 2021

PKV Res. J. Vol. 45(1), January, 2021

# Effect of Different Levels of Beetroot (*Beta vulgaris*) Juice on Sensory Evaluation and Cost of Production of Shrikhand

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## ABSTRACT

The present investigation entitled Effect of different levels of Beetroot (*Beta vulgaris*) juice on sensory evaluation and cost of production of Shrikhand was conducted at Department of Animal Husbandry and Dairy Science, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. An effort was made to standardize the optimum level of beetroot juice in the preparation of shrikhand, with main objects to evaluate sensory quality of product and to calculate cost of production. In view of this present study was carried out with five treatments including control $T_1$ and shrikhand prepared from cow milk chakka with different levels of beetroot juice i.e. 0.5 per cent, 1.0 per cent, 1.5 per cent, and 2.0 per cent in treatment $T_2$, $T_3$, $T_4$ and $T_5$, respectively. From the investigation it was observed that, the average score for body and texture of shrikhand was highest in $T_4$ (8.75) and lowest in $T_5$ (7.82). As regard for colour and appearances showed the highest score in $T_4$ (8.90) and lowest in $T_5$ (7.82) Treatment $T_4$ showed highest overall acceptability score (8.90) over other treatments. The mean overall acceptability was highest in treatment $T_4$ (8.72) followed by treatment $T_1$ (8.02), $T_2$ (8.37), $T_3$ (8.55) and $T_5$ (7.63) treatments. The manufacturing cost of product calculated on the basis of prevailing market rates of ingredients, cost of production of beetroot juice shrikhand (per kg) for treatment $T_1$, $T_2$, $T_3$, $T_4$ and $T_5$ were as Rs. 183.70, Rs. 183.50, Rs. 183.30, Rs. 183.10 and Rs. 182.90, respectively. The cost of production per kg value added shrikhand was lowest in $T_5$ (Rs. 182.90 per kg) and highest in $T_1$ (Rs.183.70 per kg). It was concluded that, acceptable quality shrikhand can be prepared by adding 1.5 per cent beetroot juice


Shrikhand is very much popular milk product in western part of the country due to its high nutritive, characteristic flavour, taste, palatable nature and possible therapeutic value. It is very refreshing particularly during summer months. It can be recommended as health food for specific patients suffering from obesity and cardiovascular disease due to its low fat and sugar contents. The amino acid methionine in the curd, which removes the excessive fat from the liver, can improve the general condition of arteriosclerosis, which usually leads to heart attack. Consumption of dahi has definite inhibitory action against certain type of cancer cells. It has nutritive goodness of fermented milk products. Tom Clifford *et al.* (2015) beetroot is a rich source of phytochemical compounds, that includes ascorbic acid, carotenoids, phenolic acid and flavonoids. Beetroot is also one of the few vegetables that contain a group of highly bioactive pigments known as betalains. Members of the betalain family are categorized as either betacyanin pigments that are red-violet in colour or betaxanthin pigments that are yellow-orange in colour. A number of investigation have reported betalains to have high antioxidant and anti-inflammatory capabilities *in vitro* and a variety of *in vivo* animal models.This has sparked interest in a possible role for beetroot in clinical pathologies characterized by oxidative stress and chronic inflammation such as liver disease arthritis and even cancer.

## MATERIAL AND METHODS

The present investigation on Preparation of shrikhand blended with beetroot (*Beta vulgaris*) juice was undertaken during 2020-21 in the Department of Animal Husbandry and Dairy Science, Post Graduate Institute, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra. Fresh, clean cow milk was received and standardized at 4 per cent fat level before preparation of chakka. used for shrikhand preparation. Beetroot vegetable was purchased from Research Farm of Department of Horticulture, PDKV, Akola and used for conducting the experiment. Method was used for

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preparation of shrikhand suggested by Aneja*et al.* (1977) with slight modification. Treatments were planned as $T_1$ (100% shrikhand as per standard (control), $T_2$ (99.5% shrikhand as per standard + 0.5 % beetroot juice), $T_3$ (99% shrikhand as per standard + 1 % beetroot juice ), $T_4$ (98.5% shrikhand as per standard + 1.5 % beetroot juice) and $T_5$ (98% shrikhand as per standard + 2 % beetroot juice). In all treatments sugar was used @ 45% by wt. of mix. The acceptability of beetroot juice blended shrikhand was measured in terms of sensory evaluation in respect of flavour, body and texture, colour and appearance and overall acceptability of the product by panel of judges by using "9 point hedonic scale". Each samples bearing code number as to avoid its identity and impartial results (Pal and Gupta, 1985). Cost structure was calculated by considering market rates of ingredients and necessary requirements. The data obtained during present investigation was statistically analyzed by adopting Completely Randomized Design (CRD) as described by (Amble 1975)

## RESULTS AND DISCUSSION

The effect of different levels of beetroot juice on mean score values of different parameters of acceptability of shrikhand.

| Treatments | Colour & appearance | Flavour | Body and texture | Overall acceptability |
|---|---|---|---|---|
| $T_1$ | 8.02 | 8.02 | 8.00 | 8.02 |
| $T_2$ | 8.22 | 8.22 | 8.25 | 8.37 |
| $T_3$ | 8.55 | 8.45 | 8.45 | 8.55 |
| $T_4$ | 8.90 | 8.72 | 8.75 | 8.72 |
| $T_5$ | 7.82 | 7.80 | 7.82 | 7.63 |
| SE(m) | 0.115 | 0.101 | 0.095 | 0.079 |
| CD at 5% | 0.350 | 0.307 | 0.288 | 0.240 |

Showed that the treatment $T_4$ was significantly superior over $T_1$, $T_2$, $T_3$ and $T_5$ treatments for colour and appearance as well as body and texture. The variation in flavour score was observed statistically significant in the different treatments (Table 1).

The data of overall acceptability score between the treatments was statistically significant. The mean score of overall acceptability of shrikhand blended with beetroot juice for treatments $T_1$, $T_2$, $T_3$, $T_4$ and $T_5$ were as, 8.02, 8.37, 8.55, 8.72 and 7.63 respectively. The treatment $T_4$ was significantly superior over $T_1$, $T_2$, $T_3$ and $T_5$ treatments. This indicates that 1.5 per cent beetroot juice blended with shrikhand recorded highest score for overall acceptability as compare to shrikhand prepared with 2 per cent beetroot juice was observed lowest score.Narayanan and Lingam (2013) reported that highest score 8.66 for 20 per cent for ripe banana shrikhand improves the overall acceptability over control.

**Cost of production:**

Cost of beetroot juice blended shrikhand was worked out and it was noted that**,** cost of production of beetroot juice blended shrikhand (per kg) for treatment $T_1$, $T_2$, $T_3$, $T_4$ and $T_5$ were Rs.183.70, 183.50, 183.30, 183.10, and 182.90, respectively (Table2). Addition of beetroot juice in shrikhand proportionally decreased the cost of production. The cost of production of blended shrikhand could be reduced further if the same can manufactured on large scale. The cost of production of non blendedshrikhand $T_1$ (control) was observed to be higher than the shrikhand prepared with addition of beetroot juice. Increased level of beetroot juice showed decreased in cost of production of shrikhand. This difference was occurs due to the addition of beetroot juice. Higher cost of production was observed in case of treatment $T_1$. However, the best treatment selected by judges was $T_4$ (addition of 1.5 per cent beetroot juice to shrikhand) and the cost of production of shrikhand in this treatment was founded to be Rs.183.10 per kg.

Mali *et al*. (2010) observed that, lowest cost of plain shrikhand was Rs.57.68 per kg while, highest cost Rs.68.58 per kg was observed in shrikhand blended with papaya pulp.Meshram (2010) and Tale (2013) also reported that shrikhand added with turmeric powder in respect to cost of production of shrikhand was slightly increase with increase in the level of turmeric powder.Bhoyar (2014) prepared shrikhand by using unripe banana pulp and reported that the cost of 1 Kg shrikhand was lowest in $T_5$ (Rs.96.67) and highest in $T_1$ (107.78). Increase level of unripe banana pulp showed slight decrease in cost of production of shrikhand.

**Table 2. Cost of preparation of beetroot shrikhand (Kg)**

| Particulars | Treatments | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $T_1$ | | $T_2$ | | $T_3$ | | $T_4$ | | $T_5$ | |
| | Qty. | Amt. (Rs) | Qty | Amt. (Rs) | Qty | Amt. (Rs) | Qty | Amt. (Rs) | Qty. | Amt. (Rs) |
| Quantity of cow milk used in ml | 1000 | 40 | 995 | 39.8 | 990 | 39.6 | 985 | 39.4 | 980 | 39.2 |
| Chakka obtained (gm) (1lit milk - 200 gm) | 200 | | 199 | | 197 | | 196 | | 195 | |
| Beetroot juice (gm) | - | | 1 | 0.10 | 2 | 0.20 | 3 | 0.30 | 4 | 0.40 |
| Sugar@45% (by weight of chakka) Rs 40/kg | 180 | 7.20 | 180 | 7.20 | 180 | 7.20 | 180 | 7.20 | 180 | 7.20 |
| Miscellaneous cost (Rs) (electricity, labour, gas) | | 25 | | 25 | | 25 | | 25 | | 25 |
| Total shrikhand obtained (gm) | 380 | 72.20 | 380 | 72.10 | 380 | 72.00 | 380 | 71.90 | 380 | 71.80 |
| Cost of shrikhand / kg. | | 183.70 | | 183.50 | | 183.30 | | 183.10 | | 182.90 |

## CONCLUSION

On the basis of results of present investigation it was concluded that, the overall acceptability of shrikhand prepared from 1.5 per cent beetroot juice had scored highest. Cost of production was decreased numerically with increase in the level of beetroot juice. Hence, it is concluded that acceptable shrikhand can be prepared by blending 1.5 per cent beetroot juice.

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Received on 22 February, 2021

PKV Res. J. Vol. 45(1), January, 2021

# Effect of Supplementation of Shredded Ginger Feeding on Growth Performance of Goat Kids

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## ABSTRACT

Present study was conducted for period of 60 days with 20 goat kids were divided into four groups on the basis of nearness to the age and weight. Four feeding treatments were studied namely $T_1$ (Natural browsing / grazing + Concentrate / day), $T_2$ (Natural browsing / grazing + Concentrate +3 Gram shredded ginger / day), $T_3$ (Natural browsing / grazing + Concentrate +6 Gram shredded Ginger / day), $T_4$ (Natural browsing / grazing + Concentrate +9 Gram shredded Ginger / day), was fulfilled requirement of goat kids in all treatments. It was observed that, readymade concentrate was containing 89.70, 19.70, 12.30, 5.25, 58.51 and 4.15 per cent of DM, CP, EE, CF, NFE and Total ash and shredded ginger containing 26.18 DM, 8.16 CP, 2.88 EE, 5.03 CF, 81.02 NFE and 2.91 Total ash percent respectively. Daily DM intake differed significantly between the treatments. The average daily DM intake was 0.346, 0.385, 0.450 and 0.420 kg/day/kids in $T_1$, $T_2$, $T_3$ and $T_4$ groups respectively. This trend thus indicated that there was increase in the daily DM intake when a shredded ginger was incorporated as concentrate in the rations of kids. Weight gain per day was found higher in $T_3$. All the kids exhibited satisfactory growth rate 0.053 to 0.071 kg per day and differences were significant. The per kg gain of body weight was higher in $T_3$ treatment. Feeding cost was desirable in $T_3$ treatment. Growth rate was higher in feeding in kids feed concentrate mixture with 6 gram shredded ginger per day than other group.

India rank second in the world goat population. In India 148.88 million population of goat which contributes about 21.40% of the world population of goats. Out of total nearly 75% Indian goats are graded as non descript. It produced 1.23 thousands metric tons of milk. In India, goat farming helps in providing self sufficiency and returns to the goat owners(Anonymous, 2019). The Osmanabadi goat is an important goat breed of Marathwada region of Maharashtra, particularly in Vidharbha landless and small farmers reared Osmanabadi goats for meat purpose. Ginger can be used for a variety of food or medicine items such as vegetables, candy, soda, pickles, and alcoholic beverages. Ginger is a fragrant kitchen spice, young ginger rhizomes are juicy and fleshy with a mild taste. They are often pickled in vinegar or sherry as a snack or cooked as an ingredient in many dishes. They can be steeped in boiling water to make ginger tea, to which honey may be addedginger can be made into candy or ginger wine. Mature ginger rhizomes are fibrous and nearly dry. The juice from ginger roots is often used as a seasoning in Indian recipes and is a 5 common ingredient of Chinese, Korean, Japanese, Vietnamese, and many south Asian cuisines for flavoring dishes such as seafood, meat, and vegetarian dishes. Fresh ginger can be substituted for ground ginger at a ratio of six to one, although the flavours of fresh and dried ginger are somewhat different.Powdered dry ginger root is typically used as flavoringfor recipes such as gingerbread, cookies, crackers and cakes, ginger ale and ginger beer. Candied ginger or crystallized ginger, know in the UK as “stem ginger” is the root cooked in suger until soft, and is the type of confectionery. Fresh ginger may be peeled beforeeating.For longer-term storage,the ginger can be placed in a plastic bag and refrigerated or frozen. In Indian cuisine, ginger is a key ingredient, especially in thicker gravies, as well as in many other dishes, both vegetarian and meatbased. Ginger has a role in traditional ayurvedic medicine. It is an ingredient in traditional Indian drinks, both cold and hot, including spiced masala chai. Raw ginger is composed of 79% water, 18% carbohydrates, 2% protein, and 1% fat, in 100 grams (a standard amount used to compare with other foods) raw ginger supplies 333 kilojules (80 kilocalories) of food energy and contains maderate amount of vitamin B6 (12% of the daily value,DV) and the dietary minerals, magnesium (12% DV) and manganese (11% DV), but otherwise is low in nutrient

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content.(Sangita Kumari and Alka Gupta, 2015) Hence, this investigation entitled Effect of supplementation of shredded ginger feeding on growth performance of goat kids.

## MATERIAL AND METHODS

The present investigation was conducted at Livestock Instructional Farm, Department of Animal Husbandry & Dairy Science Dr. P.D.K.V. Akola, for a total period of 60 days ( 31 January 2021 to 1 April 2021 excluding pre-experimental period). The objective of the experiment was to studies on supplementation of shredded ginger (Zingiber officinale) and its effect on growth performance of growing kids. Twenty goatkids between the age group of 06 to 9 months and weighing between 9 to 13 Kg were divided into four equal groups of five goat kids, in such a way that all the group were having approximately same body weight at the beginning of experiment. The selected goat kids were tested under different treatment by applying Randomized Block Design. Treatments were framed as $T_1$ Natural browsing / grazing + Concentrate, $T_2$ Natural browsing / grazing + Concentrate +3 g ginger, $T_3$ Natural browsing / grazing + Concentrate +6 g ginger and $T_4$ Natural browsing / grazing + Concentrate +9 g ginger. Feeding trial of 08 weeks duration (31 January 2021 to 1 April 2021) was conducted by providing required amount of nutrients as per Anonymous (1984) standards through prepared experiment feeds of treatments combination and keeping the grazing time as constant for all the treatment groups. All the four groups of goat kids were kept under identical standard management practices. The daily feed intake per goat kid was recorded by providing feed as per treatments during morning and afternoon and subtracting the residue of the feed left in the next day morning. The record of each goat kid was kept separately and daily matter intake was calculated. The body weight of experimental goat kids was recorded at the start of experimental for 3 consecutive days and then at weekly interval. The weight was taken in morning hours i.e. between 8 to 9 am, before watering and feeding of goat kids on weighing balance. The data obtained was subjected to the statistical analysis as described by Amble (1975)

## RESULTS AND DISCUSSION

**Dry matter intake :**

The dry matter is the most important component of the feeds and fodder. It excludes the moisture content of feed and grazing/browsing. The feed requirement of animal is based on the DM content of feed. The observations on dry matter intake and DMI/100 kg BW under different treatments is tabulated in Table 1

The mean values of daily DM intake of goat kids in four different treatments were presented in table 1 that, the values of DM intake observed in treatment groups $T_1$, $T_2$, $T_3$ and$T_4$ were 0.346, 0.385, 0.450 and 0.420 kg respectively. The daily DM intake through concentrate with shredded ginger was significantly superior in different group of goat kids. The daily DMI of goat kids was significantly higher in treatment $T_3$ over rest of the treatments.

**Table 1. Effect of shredded ginger on daily dry matter intake per kids (kg)**

| Treatments | Average body weight (kg) | Daily dry matter intake (kg) | Daily dry matter intake $100^{-1}$ kg body weight (kg) |
|---|---|---|---|
| $T_1$ | 12.39 | 0.346 | 3.20 |
| $T_2$ | 12.75 | 0.385 | 3.50 |
| $T_3$ | 13.33 | 0.450 | 3.95 |
| $T_4$ | 13.45 | 0.420 | 3.75 |
| SE (m) ± | 0.076 | 0.003 | 0.046 |
| C.D. at 5% | 0.238 | 0.008 | 0.144 |

DMI requirement as per the standard was fulfilled by intensive rearing method along with feeding of concentrate mixture to the goat kids during experimental period. The DM intake was observed more in treatment group $T_3$ followed by the treatment $T_4$,$T_2$and $T_1$ group of kids. It indicated that, the influence of incorporation 6 gram shredded ginger with concentrate mixture as per DCP and TDN requirements improves the DM intake of the experimental goat kids. The lowest DM intake kg/day observed under treatment group $T_1$.It might be due to

feeding of kids without shredded ginger. The daily dry matter intake per 100 kg body weight of goat kids of the treatment groups $T_1$, $T_2$, $T_3$ and $T_4$ were 3.20, 3.50, 3.95 and 3.75 kg, respectively. It indicated that the supplementation of 6 gram shredded gingerin treatment group $T_3$ improved the DM intake over the goat kids group of $T_1$, $T_2$ and $T_4$treatment. Dhingra and Destgir (1982) reported that goat is very efficient ruminant taking 80 per cent of its nutritive requirements through browsing. The results of Dwivedi *et al.* (2003), Roy *et al.* (2010), Bhilawade (2015), Jadhav (2016), Lalit *et al.* (2016) are also in agreement with present study that supplementation improves DM intake by kids.

**Growth performance of goat kids**

**Daily body weight gain of kids**

The observations on daily and weekly body weight gain of goat kids as affected by different treatments are presented in Table 2. A perusal of Table 2 revealed that, feeding shredded ginger treatments influenced the daily and weekly BW gain in goat kids. The values observed for weekly gain in body weight per kid were 0.371, 0.408, 0.497 and 0.478 kg in treatment groups $T_1$, $T_2$, $T_3$ and $T_4$, respectively. The corresponding values for average daily gain were 53, 58, 71 and 68 gm in treatment groups $T_1$, $T_2$, $T_3$ and $T_4$, respectively.

**Table 2. Effect of shreded ginger on daily and weekly body weight gain of kids (g)**

| Treatments | Weight gain day$^{-1}$ kid$^{-1}$ (g) | Weight gain week$^{-1}$ kid$^{-1}$ (g) |
|---|---|---|
| $T_1$ | 53 | 371 |
| $T_2$ | 58 | 408 |
| $T_3$ | 71 | 497 |
| $T_4$ | 68 | 478 |
| SE (m) ± | 0.794 | 4.532 |
| Sig C.D. at 5% | 1.543 | 11.20 |

The variation among different treatments was found statistically significant at 5 per cent level. The body weight gain was significantly ($P<0.05$) higher in goat kids of treatment group $T_3$followed by $T_4$, $T_2$ and $T_1$. Moreover, the goat kids from $T_1$ treatment maintained significantly lowest daily as well as weekly gain in BW, while the differences in respect of daily and weekly gain between $T_2$, $T_3$ and $T_4$ did differed significantly. It is therefore, clear from this trend that the kids reared with shredded ginger in diet maintained higher growth rate over feeding without shredded ginger to the kids ($T_1$). It was indicated that 6 gramshredded ginger increased the growth rate of experimental goat kids. The results reported by Ahmed et al. (2015), Adake (2015), Bansode (2017) and Toradmal (2017), Ikyume (2020) are also in agreement with present study supplementation affects higher body weight gain

**Cost structure per kg gain in BW**

The feed cost per kg body weight gain under different treatments were calculated and it was noticed that the total cost of feed per goat kid during the experimental period (60 days) was Rs. 1830, 1844.40, 1858.80 and 1873.20 under $T_1$, $T_2$, $T_3$ and $T_4$ group, respectively. The corresponding values for feed cost kg$^{-1}$ body weight gain were Rs. 575, 527, 404 and 457 in treatment $T_1$, $T_2$, $T_3$ and $T_4$group of kids, respectively. The cost of feeding day$^{-1}$ kid$^{-1}$ was 30.50, 30.74, 30.57 and 31.22 under $T_1$, $T_2$, $T_3$ and $T_4$ group. $T_4$, $T_2$ and $T_1$ indicated that higher amount of feed intake by goat kids increased the cost of feeding, though the cost of feeding is higher in $T_3$. But higher weight gain also observed in $T_3$ (4.26 kg), hence it is economical for farmer. But the cost of BW gain per kg per goat kid was observed Rs. 115, 105.40, 80.80 and 91.40 in treatment $T_1$, $T_2$, $T_3$ and $T_4$. The cost of gain in BW per kg per kid was higher in treatment $T_1$ kid and lower in treatment $T_3$. The cost of gain in BW per kg kid in treatment $T_3$ was observed Rs. 80.80. The results of Chopade et al. (2010), Ghodake *et al.* (2012), Sawant *et al.* (2013) are also in agreement with present study supplementation significantly affects cost of production in goat kids

## CONCLUSIONS

The for going results and discussion leads to concluded that, maximum growth rate (weight gain) was obtained by treatment consisting of 6 g. shredded ginger and concentrate meal day$^{-1}$. The dry matter intake was noticed more in $T_3$ (3.95) followed by $T_4$, $T_2$ and $T_1$. Total body weight gain was obtained in $T_3$ (4.26 kg) by feeding of consisting of 6 gram shredded ginger meal day$^{-1}$ to the goat kid's. The cost of feeding day$^{-1}$ treatment$^{-1}$ was lowest in $T_1$(30.50 Rs) as compare to $T_2$, $T_3$ and $T_4$ indicated that higher proportion of shredded ginger used in goat kid

feeding, increased the cost of feeding. Hence, it is concluded that growing goat kids can be efficiently raised on feeding shredded ginger supplemented diet as evident from the increased dry matter intake which is resulted into significantly more body weight gain and also improving the health of experimental kids

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Received on 7 June, 2021

PKV Res. J. Vol. 45(1), January, 2021

# Effect of Challenge Feeding on DMI and Body Weight Gain of Newly Born Calves in Crossbred Cows

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## ABSTRACT

Present study is planned to find out the effect of challenge feeding on performance economics of Jersey crossbred cows. Experiment was conducted for three years, during each year 18 crossbred (Jersey) cows were selected and divided as 06 cows in each group on the basis of nearness to previous lactation milk production (2rd and 4th lactation) and allotted as per treatments for their comparative studies. Challenge feeding trials were conducted from 60 days before probable calving as Dry roughage ad lib + Green roughage + 1 kg concentrate for maintenance ($T_1$),Dry roughage ad lib + Green roughage + 1 kg conc. for maintenance + 2.0 kg conc. as challenge feed ($T_2$), Dry roughage ad lib + Green roughage + 1 kg conc. for maintenance + 2.5 kg conc. as challenge feed ($T_3$). 10kg green roughages were provided constant to every animal of all experimental groups. On the basis of observations recorded in the present investigation it is concluded that, the overall pooled mean of DMI per 100 kg BW during the postpartum period were 3.123, 3.323 and 3.48 kg in $T_1$, $T_2$ and $T_3$ treatment groups respectively. Nutritive value of different nutrients i.e. CP, DCP and TDN was increased due to increase in the rate of feeding of concentrate as challenge feed as 7.84,10.01 and 10.73 for CP, 4.72, 5.68 and 6.28 for DCP 53.05, 57.11 and 64.91 for TDN and Nutritive Ratio was 1:10.23, 1: 9.05 and 1:9.33 for treatment $T_1$, $T_2$ and $T_3$, respectively. The pooled mean birth weights of calves in all treatment groups were 16.33, 20.41 and 22.65 kg respectively. The birth weight of calves was increased by 24.98 and 38.70 percent in treatment $T_2$and $T_3$ group respectively.


Animal Husbandry is the most important allied / subsidiary activities/ business to the farmers for instant cash, nutritional and food safety for his family and soil health, thus it plays important role in the socio-economic status of India. In India, concentrate feeding to animal is neglected due to poor economic condition of farmers (Anonymous, 2018). The milch animals are deprived of concentrate during dry period as well as milking stage and thus these dairy animals are deprived of essential nutrients. These nutrients are very much essential to fulfill the requirement of growth and maintenance of foetus, placenta, and uterus as well as to replenish the body tissue losses due to milk production postpartum. The lack of concentrate feeding along with low availability of good quality fodders is the major reason behind the poor productivity of our cattle population.

The period from two months precalving to two months post calving which include the transition period is the most stressful period in the annual cycle of dairy cows. Physiologically and nutritionally it is very stressful period, particularly as feed intake is reduced, while the demand for support of featus growth and initiation of milk synthesis are increased. During late gestation, feed intake is reduced (Olsson,1996, Goff and Horst, 1997 and Murphy, 1999), particularly last few days of pregnancy, neglecting in nutritional feed adversely affect growth and health of featus. Suboptimal transition from dry period to lactation can decrease peak milk yield and persistency and hence total milk production, decrease reproduction performance and can easily erase the entire profit potential for an individual cow in that lactation (Drackley, 1999).

In challenge feeding there is a stepwise increase in amount of concentrate fed to pregnant animals**,** which not only improves the production performance of animals but also improve reproduction performance and helps in reducing the incidences of metabolic disorders. Therefore the present study is planned to find out the effect of challenge feeding on daily dry matter Intake (DMI) and body weight of calves.

## MATERIAL AND METHODS

**Selection of Cow :** During each year 18 crossbred (Jersey) cows were selected and divided as 06 cows in each group on the basis of nearness to previous lactation milk production (2rd and 4th lactation) and allotted as per treatments for their comparative studies.

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**Feeding :**Dry fodder Jawar kuttiwas provided ad lib. to all experimental animals, 10 kg fix green fodder was provided(2 kg berseem and 8 kg Hy. Napier)and concentrate was provided as per treatments.

**Feeding of milch animals after calving:**For all experimental animals of three treatments dry fodder adlib. + green as per thumb rule + concentrate 1kg for maintenance and 1kg additional for every 3.0 lit milk production per day was provided.

**Other management:** Common recommended practices for watering, housing and other managements was adopted uniformly for all experimental groups**.**

**Treatments Details**:

| **Days pre-partum** | **60 days to 22 days before calving** |
|---|---|
| **Control group($T_1$)** | Dry roughage ad lib + Green roughage + 1 kg concentrate for maintenance |
| **Treatment group($T_2$)** | Dry roughage ad lib + Green roughage + 1 kg conc. for maintenance + 1.5 kg conc. as challenge feed |
| **Treatment group($T_3$)** | Dry roughage ad lib + Green roughage + 1 kg conc. for maintenance + 2.0 kg conc. as challenge feed |
| **Days pre-partum** | **21 days to 0 days before calving** |
| **Control group($T_1$)** | Dry roughage ad lib + Green roughage + 1 kg concentrate for maintenance |
| **Treatment group ($T_2$)** | Dry roughage ad lib + Green roughage + 1 kg conc. for maintenance + 2.0 kg conc. as challenge feed |
| **Treatment group($T_3$)** | Dry roughage ad lib + Green roughage + 1 kg conc. for maintenance + 2.5 kg conc. as challenge feed |

(10kg green roughages was provided constant to every animal of all experimental group)

**Statistical analysis :** Data obtained in the present investigation was statistically analyzed by applying RBD as described by Gomez and Gomez (1984).

**Table 1. Effect of challenge feeding on average daily dry matter intake (kg) during pre-partum period**

| Treatments | Daily Dry Matter intake(kg) | | | Pooled mean |
|---|---|---|---|---|
| | 2018-19 | 2019-20 | 2020-21 | |
| $T_1$ (1 kg Conc.) | 6.90 | 7.85 | 7.85 | 7.533 |
| $T_2$ (3 kg Conc.) | 8.85 | 9.05 | 9.15 | 9.017 |
| $T_3$ (3.5 kg Conc.) | 10.50 | 10.60 | 10.75 | 10.617 |
| F-test | Sig. | Sig. | Sig. | Sig. |
| SE (m) ± | 0.69 | 0.75 | 0.85 | 0.763 |
| CD at 5% | 2.10 | 2.30 | 2.60 | 2.333 |

**Table 2. Effect of challenge feeding on average daily dry matter intake/100kg body weight (kg) during pre-partum**

| Treatments | Daily Dry MatterIntake/100 kg BW | | | Pooled mean |
|---|---|---|---|---|
| | 2018-19 | 2019-20 | 2020-21 | |
| $T_1$ (1 kg Conc.) | 2.52 | 2.55 | 2.60 | 2.56 |
| $T_2$ (3 kg Conc.) | 2.85 | 2.84 | 2.90 | 2.86 |
| $T_3$ (3.5 kg Conc.) | 2.90 | 3.16 | 3.20 | 3.09 |
| F-test | Sig | Sig. | Sig. | Sig |
| SE (m) ± | 0.021 | 0.041 | 0.041 | 0.033 |
| CD at 5% | 0.063 | 0.122 | 0.123 | 0.103 |

## RESULTS AND DISCUSSION

The data obtained in respect to objectives were statistically analyzed, tabulated, presented and discussed as fallows.

It was observed from Table 1 that the daily DM intake was significantly differed among the treatments. The average daily intake of dry matter during pre-partum period pooled mean was 7.53, 9.02 and 10.62 kg cows$^{-1}$ in $T_1$, $T_2$ and $T_3$ group, respectively.

It was noticed that the daily DM intake per 100 kg BW was significantly differed among the treatments. The cows from $T_3$ group consumed more DM than that of $T_1$ and $T_2$ group. Higher intake of DM per 100 kg body weight was observed in treatment $T_3$ and lowest in $T_1$. This trend thus, indicates that there was increase in the daily DM intake when the extra concentrate had given during pre-partum period in crossbred cows. The animals in the experimental groups, consumed significantly ($P<0.05$) higher quantity of concentrate mixture, green fodder and Jowar kutti, during the pre-partum periods, as compared to those in the control group resulting in significantly ($P<0.05$) higher total daily DMI. The pooled means of total daily dry matter intake per 100 kg body wt. during pre-partum periods of the animals of the three treatment groups $T_1$, $T_2$ and $T_3$ were 2.56, 2.86 and 3.09 kg respectively and were significantly differed among the treatment. Goff and Horst (1997), Murphy( 1999),Alam*et al.*(2009), Singh *et al* . (2016) and Deen *et al.* (2018) recorded that supplementation of protein rich diet increase the dry matter intake (5 to 15 %).

**Effect on Nutritive values of different feeding treatment:** Nutritive values of different feeding treatments were tabulated, statistically analyzed and presented in Table 3.

**Table 3. Nutritive values of different feeding treatments (Pooled means)**

| Treatment | Nutritive value % | | | |
|---|---|---|---|---|
| | CP | DCP | TDN | NR |
| $T_1$ (1 kg Conc.) | 7.84 | 4.72a | 53.05b | 1:10.23 |
| $T_2$ (3 kg Conc.) | 10.01 | 5.68b | 57.11c | 1:9.05 |
| $T_3$ (3.5 kg Conc.) | 10.73 | 6.28c | 64.91a | 1:9.33 |

It is observed from Table 3 that, nutritive value of different nutrients i.e. CP, DCP and TDN was increased due to increase in the rate of feeding of concentrate as challenge feed as 7.84,10.01 and 10.73 for CP, 4.72, 5.68 and 6.28 for DCP53.05, 57.11 and 64.91 for TDN and Nutritive Ratio was 1:10.23, 1: 9.05 and 1:9.33 for treatment $T_1$, $T_2$ and $T_3$, respectively, this indicates the significant effect of feeding of more concentrate as challenge feeding to the cows.

**Effect on body weight of newly born calves:**Data obtained pertaining to effect on body weight of newly born claves was tabulated, analyzed and presented in Table 4.

**Table 4. Effects of challenge feeding on birth weight (kg) of calves.**

| Treatments | Average birth weight of calves (kg) | | | Pooled mean |
|---|---|---|---|---|
| | 2018-19 | 2019-20 | 2020-21 | |
| $T_1$ (1 kg Conc.) | 16.50 | 16.20 | 16.30 | 16.33 |
| $T_2$ (3 kg Conc.) | 19.75 | 20.10 | 21.40 | 20.41 |
| $T_3$ (3.5 kg Conc.) | 21.75 | 21.80 | 21.90 | 21.82 |
| SE (m) ± | 0.79 | 0.83 | 0.82 | 0.80 |
| CD at 5% | 2.40 | 2.54 | 2.55 | 2.41 |

It is noticed from the table 4 that the pooled mean birth weights of calves in all treatment groups were 16.33, 20.41 and 22.65 kg, respectively. The calves born to cows of challenge fed group $T_2$ and $T_3$ were about 4.08 and 6.32 kg heavier than calves born to cows of $T_1$ group and statistically the difference was significant. The birth weight of calves was increased by 24.98and38.70 percent in treatment $T_2$ and $T_3$ group, respectively. This trend was observed might be due to feeding of challenge feeds to the crossbred cows.The higher pre-partum feeding regime for the treatment group during the pre-partum period might have been resulted in higher mean calf birth weight as compared to control group. Olsson(1996), Goff and Horst (1997), Murphy (1999), Alam *et al.* (2009) and Deen *et al.* (2018) also reported that balance diet and supplementation of protein shows positive effect on the body weight gain of cow and calves 5 to 10 per cent and 15 to 25 per cent, respectively, which supports the present results.

## CONCLUSION

On the basis of observations recorded in the present investigation it is concluded that,DMI, water intake as well as digestibility of nutrients increased due to feeding of additional concentrates as challenge feed. Body weight of newly born calves was increased i.e. 25 to 39% over control group.It is inferred that challenge fed experimental animals recorded improved growth performance.

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Received on 20 May, 2021

# Effect of Skim Milk Powder on Sensory and Chemical Quality of Low Fat Burfi

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## ABSTRACT

The present investigation was carried out in the Department of Animal Husbandry and Dairy Science, Dr PDKV Akola (Maharashtra) during the year 2020-21. With a view to utilize skim milk powder in burfi preparation, burfi was prepared with different combinations of cow milk and skim milk powder as 100:00, 80:20, 70:30, 60:40 and 50:50 in treatment $T_1$, $T_2$, $T_3$, $T_4$ and $T_5$. The samples of fresh burfi were subjected to sensory and chemical evaluation. Low fat cow milk burfi was prepared from cow milk blended with skim milk powder as 80 per cent cow milk and 20 per cent skim milk powder ($T_2$) scored highest for overall acceptability (8.62) during sensory evaluation. Also,it was found that total sugar, protein, total solids, SNF and ash content was increased. Whereas, fat and moisture was decreased with increases in the level of skim milk powder in burfi preparation. Chemical properties of low fat cow milk burfi was prepared from 80 per cent cow milk and 20 per cent skim milk powder ($T_2$) was recorded 12.83, 15.52, 48.95, 3.26, 80.54, 19.46 and 67.70 per cent of fat, protein, total sugar, ash, TS, moisture and SNF, respectively.The cost of production of acceptable burfi ($T_2$) i.e. 80 per cent cow milk blended with 20 per cent skim milk powder was Rs 269.45 $kg^{-1}$.


India ranks first in global milk production with milk production of 187.7 MT (NCAER, 2019), at growth rate of 6.62 per cent per year. The per capita availability of milk in India during 2019 was 394 g $day^{-1}$ and by 2023-24, it is estimated to increase to 592 g $day^{-1}$ (NDDB, 2019). Out of the total milk produced in India, about 46.00 per cent is consumed as liquid milk and 54.00 per cent is utilized for conversion into different products (Aneja *et al.*, 2002). Traditional dairy products and sweets have great social, religious, cultural, medicinal and economic importance have been developed over a long period with the culinary skills of homemakers and halwais. There is scope for expanding and improving the indigenous confections by introducing a variety of products by adopting improved methods and technology considering the demand of indigenous milk products in market, burfi is one of the major indigenous milk products (Shete *et al.,* 2012). It has special importance in various social celebrations and traditional occasions. Burfi is mostly served on the ceremonial occasions as puja, wedding, inaugural functions etc. Good quality burfi is characterized by moderately sweet taste, soft and slightly greasy body and smooth texture with very fine grains. Skim milk powder and cow milk contain low level of fat and useful for preparation of low fat burfi. Skim milk powder and cow milk contains 1.2-1.5 per cent and 3 to 4 per cent fat. The changing lifestyle and present day's cardiovascular diseases have become major health problems. It's the need of hour to create the low-fat food and dairy products (Praveen, 2018). The addition of SMP for fortification purposes appears to be by far the most common practice in yogurt industry (Damin *et al.,* 2009; Peng *et al*., 2009). At present rates of milk products are at very high level and not easily accordable to the medium economy peoples. Majority of consumers are health conscious considering same the present investigation was undertaken to reduce the cost and fat content of burfi by using skim milk powder in burfi to produce low fat burfi with main objectives to find out its overall acceptability and calculate cost of production.

## MATERIAL AND METHODS

The present investigation was conducted in the Department of Animal Husbandry and Dairy Science, Dr. PDKV, Akola during 2020-21. The treatment details as $T_1$ – Burfi prepared from 100 per cent cow milk (control), $T_2$ – Burfi prepared from 80 per cent cow milk + 20 per cent skim milk powder, $T_3$ – Burfi prepared from 70 per cent cow milk + 30 per cent skim milk powder, $T_4$ – Burfi prepared from 60 per cent cow milk + 40 per cent skim milk powder and $T_5$ – Burfi prepared from 50 per cent cow milk + 50 per cent skim milk powder. Ranganadhan *et al*., (2016) stated the procedure for burfi preparation as Skim milk powder mixed with cow milk and was boiled continuously with constant stirring and scraping so as to avoid burning of solids on the surface of kettle. When a semisolid

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consistency is attained, heating is discontinued. Cane sugar was added at the rate 30 per cent on the basis of khoa and blended thoroughly. The heating continued with greater control here after and the speed of stirring-cum-scrapping increased till the viscous mass reaches a semi-solid/pasty consistency. The final product ready when it showed signs of leaving the bottom and the sides of the kettle. The process line was followed with certain modifications for burfi preparation as prescribed by De, (2008). Good quality branded skim milk powder was purchased from local market and used for the experimental purpose as per treatment. Uniform quality and brand was maintained for all replications. The calculated amount of skim milk powder added according to treatments.

The quality of burfi sample was evaluated by offering the panel of judges with the help of by 9 point hedonic scale prescribed by Gupta, (1976). Moisture, fat, protein and ash were determined by the AOAC (2000) methods, while the refractometric method described by Akinsanya (1998) was used to determine the total sugar content of burfi. SNF was obtained by subtracting the percentage of fat from the percentage of total solids in burfi. The data obtained was subjected to the statistical analysis by following the Randomized Block Design (RBD) for testing their differences as per the procedure described by Gomez and Gomez (1984).The cost of production of $kg^{-1}$ burfi under various treatments was calculated by considering the prevailing retail market price for various materials i.e. milk, skim milk powder, sugar, fuel, labour charges and electricity charges.

## RESULTS AND DISCUSSION

**Sensory Evaluation of Burfi:**

**Table 1: Sensory quality of low fat cow milk burfi.**

| Treatments | Parameters | | | |
|---|---|---|---|---|
| | Flavour | Body & Texture | Colour & appearance | Overall acceptability |
| $T_1$ | 7.72 | 7.20 | 7.55 | 7.20 |
| $T_2$ | 8.42 | 8.42 | 8.75 | 8.62 |
| $T_3$ | 8.00 | 7.85 | 7.77 | 7.77 |
| $T_4$ | 6.95 | 6.80 | 7.25 | 6.90 |
| $T_5$ | 6.32 | 5.90 | 6.80 | 6.17 |
| S.E. (m) ± | 0.215 | 0.187 | 0.236 | 0.125 |
| C.D. at 5% | 0.660 | 0.581 | 0.716 | 0.388 |

**Flavour:**

The study conducted pertaining the effect of different levels of skim milk powder on the sensory quality of burfi found that, as the levels of skim milk powder increased the score for flavour increase in the burfi up to certain limit and thereafter, it decreased. Burfi prepared by using 20 per cent of skim milk powder ($T_2$) recorded highest score (8.42 out of 9) whereas lowest score (6.32 out of 9) obtained for the burfi prepared by 50 percent of skim milk powder. It was clearly indicated that treatment ($T_2$) i.e. 20 per cent skim milk powder was superior among all the treatments, which showed mild pleasant flavour. The results are agreement with Suryawanshi *et al*., (2015) reported that as increases the level of skim milk powder, the flavour also increases up to certain limit and thereafter, found decreased score of peda prepared from skim milk powder blended with cow milk. Kumar *et al.* (2016) reported that the addition of 10 per cent pineapple pulp in burfi preparation was found to be best in terms of flavour. Vijaykumar *et al*., (2020) reported that, the level of skim milk and whey protein powder increases, resulted better flavour of khoa up to certain limit and thereafter it decreased the score in low fat khoa preparation.

**Body and texture**

The score for body and texture of burfi ranged from 5.90 to 8.42. The treatment $T_2$ scored significantly highest followed by $T_1$, $T_3$, $T_4$ and $T_5$. Similarly, the score for body and texture of burfi increased up to certain limit and thereafter, it was decreased. Burfi prepared by 20 per cent skim milk powder ($T_2$) scored the highest (8.42 out of 9) while the lowest score (5.90 out of 9) recorded for the burfi prepared with 50 per cent of skim milk powder. Kumar *et al.* (2016) reported that the addition of 10 per cent pineapple pulp in burfi preparation was found to be best in terms of taste and acceptability. Vijaykumar *et al*., (2020) revealed that, the level of skim milk and whey protein powder increases, the better body and texture was increases of khoa up to certain limit and thereafter it decreased in score in low fat khoa.

**Colour and appearance:**

The study was undertaken to evaluate the effect of different levels of skim milk powder on colour and

appearance of burfi and found that, as the levels of skim milk powder increased, simultaneously increases in the colour and appearance score of burfi up to some extent and thereafter, it was decreased. Burfi prepared using with 20 per cent skim milk powder ($T_2$) recorded highest score (8.75 out of 9) wherever lowest score (6.80 out of 9) obtained for the burfi prepared with 50 per cent of skim milk powder. The results are in agreement with Suryawanshi *et al*. (2015) observed that as the level of skim milk powder increased the colour and appearance score of peda increases up to certain limit and thereafter decreased score. Vijaykumar *et al*. (2020) observed that, the level of skim milk and whey protein powder increases, resulted better colour and appearance of khoa increases up to certain limit and thereafter it decreased in score in low fat khoa.

**Overall acceptability**

The score for overall acceptability of burfi obtained highest score (8.62 out of 9) that was evaluated by panel of judges for 20 per cent of skim milk powder ($T_2$), while the lowest score (6.17 out of 9) was rated to burfi prepared with 50 per cent of skim milk powder ($T_5$) level. This indicated that, on the basis of sensory evaluation the quality of burfi gained highest score for treatment ($T_2$) which included 20 per cent skim milk powder compared to rest of treatments. The results are in agreement with Suryawanshi *et al*. (2015) observed that as the level of skim milk powder increased the overall acceptability of peda increases up to certain limit and thereafter it was decreased score 18.91 to 15.00. Kumar *et al*. (2016) reported that the addition of 10 per cent pineapple pulp in burfi preparation was found to be best in terms overall acceptability. Vijaykumar *et al*. (2020) observed that, the level of skim milk and whey protein powder increases, resulted better overall acceptability of khoa increases up to certain limit and thereafter it was decreased in score in low fat khoa. Patel (2011) reported that, SMP-fortified yogurts fresh buttermilk powder was used up to 50 per cent as a replacement in yogurt produced an acceptable soft and smooth textured yogurt.

**Chemical properties of low fat burfi**

**Table 2 : Average chemical composition of low fat burfi (%).**

| Treats. | Parameters | | | | | | |
|---|---|---|---|---|---|---|---|
| | Fat | Protein | Total sugar | Ash | Total solids | Mois-ture | Solid not fat |
| $T_1$ | 15.75 | 13.16 | 45.48 | 2.66 | 77.05 | 22.95 | 61.30 |
| $T_2$ | 12.83 | 15.52 | 48.93 | 3.26 | 80.54 | 19.46 | 67.70 |
| $T_3$ | 11.38 | 16.70 | 50.63 | 3.56 | 82.27 | 17.73 | 70.89 |
| $T_4$ | 9.93 | 17.89 | 52.39 | 3.86 | 84.07 | 15.93 | 74.14 |
| $T_5$ | 8.47 | 19.07 | 54.12 | 4.16 | 85.82 | 14.18 | 77.35 |
| S.E. (m)± | 0.232 | 0.151 | 0.087 | 0.051 | 0.241 | 0.240 | 0.168 |
| C.D. at 5% | 0.724 | 0.471 | 0.271 | 0.158 | 0.751 | 0.748 | 0.524 |

**Fat content of Burfi**

The average fat content in burfi was decreased in case of added the skim milk powder. The fat content of burfi prepared under the treatment $T_1$, $T_2$, $T_3$, $T_4$ and $T_5$by utilization of skim milk powder were 15.75, 12.83, 11.38, 9.93, and 8.47 per cent, respectively. The results indicated that fat content was highest in burfi prepared without addition of skim milk powder ($T_1$). This clearly showed that as the quantity skim milk powder increases the fat content in the burfi was reduced. This might be due to low fat content in skim milk powder. Suryawanshi (2012) conducted study on quality of peda from skim milk powder blended with cow milk observed as the level of skim milk powder increased the fat content declined from $T_1$ to $T_5$ (15.76 to 0.80 %). Kumar *et al.* (2016) reported that, the fat content was reduced by addition on 10 per cent of pineapple pulp in burfi preparation. Present findings are in agreement with the Chaudhari (2015) and Tanuja *et al*. (2017).

**Protein content of Burfi**

The protein content in low fat burfi was found higher in treatment ($T_5$) 19.07 per cent and lowest in treatment ($T_1$) 13.16 per cent. The protein content in all treatments significantly differed from each other and it was increased with the increases the level of skim milk

powder in burfi preparation. This is might be due to the high amount of protein in skim milk powder. Nearly closed findings noted by Satav (2014) reported that as the levels of walnut powder increases, there was increased (14.90 to 16.30 %) in the level of protein content in burfi. Also, Jadhav (2015) reported that, increases the level of gram flour, there was increased in the level of protein content in burfi (12.59 to 16.48 %). On the other hand, Kumar *et al.* (2016) reported that decreased protein content with increased the level of pineapple pulp in burfi preparation.

**Total sugar content of Burfi**

The addition of skim milk powder in the preparation of burfi, significantly changes the total sugar content. The average values of total sugar content in burfi prepared under the different treatment $T_1$, $T_2$, $T_3$, $T_4$ and $T_5$ were 45.48, 48.93, 50.63, 52.39 and 54.12 per cent, respectively. This indicated that as the skim milk powder level increased, the total sugar content in burfi also increased. This might be due to high content of total sugar in skim milk powder. The present findings are in agreement with Patil (2012) reported that as the level of dried date increased with increases total sugar content in burfi from 46.90 to 53.17 per cent. Kumar *et al.* (2016) reported that increased total sugar content with increases the level of pineapple pulp in burfi preparation.

**Ash content of Burfi**

The ash content in the burfi prepared by addition of skim milk powder at the rate 0 per cent ($T_1$), 20 per cent ($T_2$), 30 per cent ($T_3$), 40 per cent ($T_4$), and 50 per cent ($T_5$) were 2.66, 3.26, 3.56, 3.44, 3.86 and 4.16 per cent, respectively. The ash per cent was highest (4.16 per cent) in burfi prepared with addition of 50 per cent of skim milk powder ($T_5$). Suryawanshi (2012) conducted study on quality of peda from skim milk powder blended with cow milk observed as the level of skim milk powder increased the ash content increased from 2.00 to 2.20 per cent. Ash content increased due to high ash content in skim milk powder. Also, the results of present study are in agreement with Kapare (2017) studied on preparation of burfi blended with finger millet, ash content was increases in burfi. Kumar *et al*. (2016) revealed that, the observation was contradictory regarding the ash content in pineapple burfi.

**Total solids content of Burfi**

The total solids content was higher in treatment $T_5$ as 85.82 per cent and treatment wise increasing trend of total solids was observed as ($T_1$) 77.05, ($T_2$) 80.54, ($T_3$) 82.27, ($T_4$) 84.07, ($T_5$) 85.82 per cent. The total solids content in the final product was increased with increasing level of skim milk powder. Patil (2012) conducted study on utilization of dried date in preparation of burfi as the level of dried date increased the total solids content increases from $T_1$ to $T_5$ (82.22 to 84.24 %), Total solids content increased might be due to high total solids content in dried date. Moreover, Satav (2014) reported that, the increased total solids content with increases the level of walnut powder in burfi from 83.16 to 83.85 per cent.

**Moisture content of Burfi**

Moisture content in the burfi prepared by addition of skim milk powder at 0 per cent ($T_1$), 20 per cent ($T_2$), 30 per cent ($T_3$), 40 per cent ($T_4$) and 50 per cent ($T_5$) were 22.95, 19.46, 17.73, 15.93, and 14.18 per cent, respectively. The moisture per cent was significantly highest (14.18 % in burfi prepared without addition of skim milk powder ($T_1$) while, moisture content was less (14.18 per cent) in $T_5$ treatment. Satav (2014) reported that, increased in the level of walnut powder with decreases the moisture content in burfi.

**Solid Not Fat content**

The addition of skim milk powder in burfi preparation significantly changed the solid not fat content in burfi. The average value of solid not fat content in burfi prepared under different treatments $T_1$, $T_2$, $T_3$, $T_4$ and $T_5$ were 61.30, 67.70, 70.89, 74.14 and 77.35 per cent, respectively. SNF was found significantly highest in $T_5$ treatment (77.35 %). It clearly indicated that as skim milk powder level was increased in burfi preparation, the solid not fat content in burfi also increased. This might be due to more SNF content was found in skim milk powder. The results are correlated with Hukare (2015) reported that, increased in the level of custard apple pulp, there was increases SNF content in low fat milk shake from 19.46 to 22.12 per cent.

## CONCLUSION

On the basis of investigation results obtained it may concluded that Sensory quality of burfi in respect of flavour, colour and appearance, body and texture and overall acceptability showed that, 20 per cent of skim milk powder in the preparation of burfi was acceptable. The chemical properties of low fat burfi like protein, total sugar, ash, total solids and solid not fat per cent was increased. Whereas, fat and moisture was decreased with increases in the level of skim milk powder in burfi preparation.The cost of burfi was decreased with the increased in the level of skim milk powder. The cost of most acceptable burfi prepared with 20 per cent skim milk powder was Rs. 269.45 $kg^{-1}$.

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Received on 25 May, 2021

PKV Res. J. Vol. 45(1), January, 2021

# Cost, Returns and Profitability of Turmeric in Akola District

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## ABSTRACT

The study was conducted to find out cost, returns and profitability of turmeric in Akola district of Vidarbha region of Maharashtra. The study was conducted in Patur and Akot tahsils of Akola district based on purposive samplingas there is concentration of turmeric area in Patur and Akot tahsils. A sample of 90 turmeric growers was selected based on random sampling during the year 2018-2019 based on primary data with the objective to study the cost, returns and profitability of turmeric in Akola district. It was revealed that, per hectare cost of cultivation of turmeric at Cost '$C_3$' was highest in the large farmers i.e. Rs. 274611 followed by medium farmer Rs. 265943and small farmer Rs. 250789 and at overall level Rs. 267320. The average yield and gross returns per hectare increased with the increase in size of farms. The average yield of turmeric crop was 69.05 qt ha$^{-1}$. The benefit cost ratio of turmeric at Cost '$C_3$' was 1.82 in small farmer, 1.87 in medium farmer, 1.90 in large farmer and 1.88 in overall farmer which indicating economical profitability of turmeric cultivation in the study areas.


Turmeric is one of the most important spices of India and a traditional crop having very good commercial value for spice oil and oleoresins. India is popularly known as the "Spice Bowl of the World" for production of variety of spices with superior quality. Turmeric is called as Indian saffron and it is one among the important commercial crops grown in India, scientifically it is known as *Curcuma longa* Linn. and belongs to family *Zingiberaceae*. Its native of southern Asia and cultivated in India, from very ancient times. It is called "Haridra" in Sanskrit, "Haldi" in Hindi. It is versatile commodity with innumerable uses. It has achieved the most important place in each household, also demand in number of countries of the world. Turmeric is valuable cash crop for cultivators, as it is ready cash crop.

The total area of turmeric in India during 2017-2018 was 237.96 thousand ha. and production was 1132.72 thousand MT with productivity of 4.76 MT ha$^{-1}$. The area under turmeric in Maharashtra during 2017-2018 was 15.88 thousand ha and production was 190.09 thousand MT with productivity of 11.97 MT ha$^{-1}$ (Anonymous, 2018). The districts growing turmeric in Maharashtra was mainly Satara, Sangli, Kolhapur, Hingoli, Parbhani, Nanded and some part of Vidarbha region. The people from Akola district change their attitude towards the production of turmeric. In Akola district, it has been reported that the crop has occupied an area of about 179 ha. and production of 64.22 MT with productivity of 0.38 MT ha$^{-1}$ during 2018-2019. The turmeric crop has assumed prominent place in the economy of the cultivations of Akola district. The crop is intensively grown in Patur and Akot tahsils of Akola district (Annonymous, 2018).

## MATERIAL AND METHODS

The study was conducted in Patur and Akot tahsils of Akola district based on purposive sampling as there is concentration of turmeric area in Patur and Akot tahsils. A sample of 90 turmeric growers was selected based on random sampling during the year 2018-19 based on primary data.From each tahsil five villages selected i.e. total ten villages were selected purposively. From Patur tahsil selected villages were Deulgaon, Agikhed, Kothari khurd, Pastul, Sasti and from Akot tahsil Panaj, Amboda, Akot, Umra and Makrampur were selected. From each village nine farmers were selected randomly. Overall ninety turmeric cultivators were selected for the present study.The objective to study the cost of cultivation of turmeric, the standard cost concept i.e. Cost $A_1$, Cost $A_2$, Cost $B_1$, Cost $B_2$, Cost $C_1$, Cost $C_2$ and Cost $C_3$ used and cost-benefit ratio was used in present analysis.

The standard cost concept i.e. Cost $A_1$, Cost $A_2$, Cost $B_1$, Cost $B_2$, Cost $C_1$, Cost $C_2$ and Cost $C_3$ was used in present analysis.

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**Cost $A_1$:** All variable cost excluding family labour cost and including depreciation

**Cost $A_2$:** Cost $A_1$ + Rent paid for leased-in land

**Cost $B_1$:**Cost $A_1$ + Interest value of owned fixed capital assets (excluding land).

**Cost $B_2$:** Cost $B_1$ + Rental value of owned land (net of land revenue) and rent paid for leased-in land.

**Cost $C_1$:** Cost $B_1$ + imputed value of family labour.

**Cost $C_2$:**Cost $B_2$ + imputed value of family labour.

**Cost $C_3$:**Cost $C_2$ + 10 per cent of Cost $C_2$(on account of managerial functions performed by farmers)

**Gross and Net returns**

**Gross returns**

Gross return of the farmers under the present study was estimated from returns obtained from sale of main produce.

**Net returns**

Net return was computed at different costs i.e. Cost $A_1$, Cost $A_2$, Cost $B_1$, Cost $B_2$, Cost $C_1$, Cost $C_2$ and Cost $C_3$ by deducting respective costs from the gross returns.

**Benefit-cost ratio**

It was calculated at Cost $A_1$, Cost $A_2$, Cost $B_1$, Cost $B_2$, Cost $C_1$, Cost $C_2$ and Cost $C_3$ by dividing gross income by respective cost.

## RESULTS AND DISCUSSION

**The Cropping Pattern of Selected Turmeric Growers**

The percentage area allocated to different crops with reference to gross cropped area by the selected turmeric growers has been presented in Table 1.

It is observed from Table 1 that, the contribution of kharif crops was highest i.e. 67.74 per cent for small, 70.02 per cent for medium and 66.62 per cent for large farmers followed by Rabi crops as 30.88, 27.03 and 23.96 per cent respectively. The per cent share of area under perennial crops was 1.38, 2.46 and 8.81 per cent for small, medium and large farmers.

**Table 1. Cropping pattern of selected turmeric growers (ha.)**

| S.N. | Particulars | Size group | | | |
|---|---|---|---|---|---|
| | | Small | Medium | Large | Overall |
| **A** | **Kharif Crop** | | | | |
| 1. | Soybean | 0.83 | 1.48 | 1.46 | 1.26 |
| | | (38.25) | (36.36) | (20.74) | (29.29) |
| 2. | Cotton | 0.18 | 0.40 | 1.01 | 0.53 |
| | | (8.29) | (9.83) | (14.35) | (12.35) |
| 3. | Tur | 0.14 | 0.27 | 1.02 | 0.48 |
| | | (6.45) | (6.63) | (14.49) | (11.11) |
| 4. | Turmeric | 0.32 | 0.70 | 1.20 | 0.74 |
| | | (14.75) | (17.20) | (17.05) | (17.25) |
| | Total | 1.47 | 2.85 | 4.69 | 3.00 |
| | | (67.74) | (70.02) | (66.62) | (70.01) |
| **B** | **Rabi Crop** | | | | |
| 1. | Wheat | 0.29 | 0.42 | 1.06 | 0.59 |
| | | (13.36) | (10.32) | (15.06) | (12.91) |
| 2. | Gram | 0.23 | 0.41 | 0.48 | 0.37 |
| | | (10.60) | (10.07) | (6.06) | (8.70) |
| 3. | Onion | 0.15 | 0.27 | 0.20 | 0.21 |
| | | (6.91) | (6.63) | (2.84) | (5.46) |
| | Total | 0.67 | 1.10 | 1.74 | 1.17 |
| | | (30.88) | (27.03) | (23.96) | (27.08) |
| **C** | **Perennial Crop** | | | | |
| 1. | Orange | 0.01 | 0.04 | 0.41 | 0.15 |
| | | (0.46) | (0.98) | (5.82) | (4.28) |
| 2. | Banana | 0.02 | 0.06 | 0.21 | 0.10 |
| | | (0.92) | (1.47) | (2.98) | (2.70) |
| | Total | 0.03 | 0.10 | 0.62 | 0.25 |
| | | (1.38) | (2.46) | (8.81) | (6.98) |
| **D** | **Gross cropped Area** | 2.17 | 4.07 | 7.04 | 4.15 |
| | | (100) | (100) | (100) | (100) |

(Figures in parentheses indicate percentage to the gross cropped area)

**Cost of Cultivation of Selected Turmeric Growers**

The cost of cultivation is helpful for crop planning therefore in order to know the cost and profitability, the cost of cultivation of turmeric for small, medium and large farmer was workout and presented in Table 1.

**Cost of Cultivation of Turmeric for Small Farmer**

It is revealed that from the table2 that, the per hectare cost of cultivation of Turmeric for small farmers at cost $A_1$, cost $A_2$, cost $B_1$, cost $B_2$, cost $C_1$, cost $C_2$ and cost $C_3$ were Rs. 121966, Rs. 121966, Rs. 125159, Rs. 201061, Rs. 152087, Rs. 2279909 and Rs. 250789, respectively. The major share of cost of cultivation goes towards cost $A_1$ and cost $A_2$ (48.63 %). In cost $A_1$, share of rhizome was 18.80 per cent, hired human labour 14.82 per cent, bullock labour 1.87 per cent, manure 1.99 per cent, fertilizers 4.73 per cent indicating that, all the above inputs are cash inputs. The cost $B_1$ contributes to 49.91 per cent, cost 'B2' contribute 80.17 per cent. The share of family labour was 10.74 per cent. The per hectare yield obtained by small farmers was 66.74 quintals with gross return of Rs. 456468. In case of small size group, the per quintal cost of production was Rs. 3416.

**Cost of cultivation of Turmeric for Medium farmer**

It is seen from the table 2 that, the per hectare cost of cultivation of Turmeric grown by the medium group farmers at cost $A_1$, cost $A_2$, cost $B_1$, cost $B_2$, cost $C_1$, cost $C_2$ and cost $C_3$ were Rs. 129457, Rs. 129457, Rs. 132939, Rs. 215456, Rs. 159250, Rs. 241767 and Rs. 265943 respectively. The major share of cost of cultivation goes towards cost $A_1$ and cost $A_2$ (48.68 %). In cost $A_1$, share of rhizome was 19.32 per cent, hired human labour 14.08 per cent, bullock labour 1.23 per cent, manure 1.89 per cent, fertilizers 4.25 per cent indicating that, all the above inputs are cash inputs. The cost $B_1$ contributes to 49.99 per cent, cost 'B2' contribute 81.02 per cent. The share of family labour was 9.89 per cent. The per hectare yield obtained by medium farmers was 68.29 quintals with gross return of Rs. 496171. In case of medium size group, the per quintal cost of production was Rs. 3540

**Cost of Cultivation of Turmeric for Large Farmers**

The $ha^{-1}$ cost of cultivation of Turmeric at cost $A_1$, cost $A_2$, cost $B_1$, cost $B_2$, cost $C_1$, cost $C_2$ and cost $C_3$ were Rs. 133491, Rs. 133491, Rs. 137120, Rs. 224128, Rs. 162638, Rs. 249646 and Rs. 274611, respectively. The major share of cost of cultivation goes towards cost $A_1$ and cost $A_2$ (48.61 %). In cost $A_1$, share of rhizome was 19.31 per cent, hired human labour 13.91 per cent, bullock labour 1.00 per cent, manure 1.87 per cent, fertilizers 3.86 per cent indicating that, all the above inputs are cash inputs. The cost $B_1$ contributes to 49.93 per cent, cost $B_2$ contribute 81.62 per cent. The share of family labour was 9.29 per cent. Per hectare yield obtained by large farmers was 69.93 quintals with gross return of Rs. 523126. In case of large size group, per quintal cost of production was Rs. 3570.

**Cost of Cultivation of Turmeric for Overall Farmers**

The per hectare cost of cultivation of Turmeric at cost $A_1$, cost $A_2$, cost $B_1$, cost $B_2$, cost $C_1$, cost $C_2$ and cost $C_3$ were Rs. 130066, Rs. 130066, Rs. 133483, Rs. 216979, Rs. 159522, Rs. 243018 and Rs. 267320, respectively. The major share of cost of cultivation goes towards cost $A_1$ and $A_2$ (48.66 %). In cost $A_1$, share of rhizome was 19.23 per cent, hired human labour 14.12 per cent, bullock labour 1.22 per cent, manure 1.90 per cent, fertilizers 4.14 per cent indicating that, all the above inputs are cash inputs. The cost $B_1$ contributes to 49.93 per cent, cost '$B_2$' contribute 81.17 per cent. The share of family labour was 9.74 per cent. Yield obtained by overall farmers was 69.05 quintals $ha^{-1}$ with gross return of Rs. 502047. In case of overall size group, the cost of production $q^{-1}$ was Rs. 3519. The results are different i.e. Cost A, Cost B & Cost C. (Kadte *et al*, 2018).

**Cost, Returns and Profitability from Turmeric**

Cost, returns and profitability of the turmeric $ha^{-1}$ was workout for small, medium and large farmers were presented in table 3.

Production of turmeric $ha^{-1}$ for small, medium and large farmer was 66.74, 68.29 and 69.93 quintals, respectively. At overall level, it was 69.05 q $ha^{-1}$. The gross returns from turmeric at $C_3$ were Rs. 456468, Rs. 496171 and Rs. 523126 for small, medium and large group. At overall level, the gross return was Rs. 502047.28. Whereas the cost of cultivation at $C_3$ of these groups have been estimated to be Rs. 250789, Rs. 265943 and Rs. 274610, respectively. The overall cost required for cultivation of turmeric at cost $C_3$ was Rs. 267320. Net returns $ha^{-1}$ at cost $C_3$ received by small, medium and large cultivator was Rs. 205679, Rs. 230228 and Rs. 248516. At an overall level, the net return was Rs. 234727. The benefit-cost ratio at cost $C_3$ for small, medium and large group turmeric growerwas

**Table 2: Cost of Cultivation of Turmeric (ha$^{-1}$)**

| S. N. | Item | Unit | | Small | | | Medium | | | Large | | | Overall | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Input ha$^{-1}$ | Total Cost ha$^{-1}$ | % to Cost $C_3$ | Input ha$^{-1}$ | Total Cost ha$^{-1}$ | % to Cost $C_3$ | Input ha$^{-1}$ | Total Cost ha$^{-1}$ | % to Cost $C_3$ | Input ha$^{-1}$ | Total Cost ha$^{-1}$ | % to Cost $C_3$ |
| 1 | Hired Human Labour | Male | Days | 78.79 | 15929 | 6.35 | 79.69 | 1605 7 | 6.04 | 81.87 | 16312 | 5.94 | 80.12 | 16157 | 6.04 |
| | | Female | Days | 141.98 | 21228 | 8.46 | 142.53 | 21384 | 8.04 | 144.17 | 21882 | 7.97 | 142.89 | 21596 | 8.08 |
| 2 | Bullock Labour | | (Pair days) | 8.71 | 4687 | 1.87 | 6.41 | 3270 | 1.23 | 5.27 | 2741 | 1.00 | 6.25 | 3269 | 1.22 |
| 3 | Machine charges | | Hours | 4.06 | 1217 | 0.49 | 5.27 | 1581 | 0.59 | 7.27 | 2193 | 0.80 | 6.03 | 1811 | 0.68 |
| 4 | Rhizome | | QTLS. | 23.57 | 47143 | 18.80 | 25.69 | 51374 | 19.32 | 26.49 | 53023 | 19.31 | 25.70 | 51410 | 19.23 |
| 5 | Manures | | QTLS. | 49.96 | 4995 | 1.99 | 49.89 | 5033 | 1.89 | 50.09 | 5129 | 1.87 | 49.98 | 5073 | 1.90 |
| 6 | Fertilizer | N | Kg. | 196.34 | 3860 | 1.54 | 201.28 | 3867 | 1.45 | 195.32 | 3758 | 1.37 | 197.65 | 3813 | 1.43 |
| | | P | Kg. | 107.84 | 4150 | 1.65 | 90.31 | 3469 | 1.30 | 82.55 | 3010 | 1.10 | 93.57 | 3369 | 1.26 |
| | | K | Kg. | 96.54 | 3861 | 1.54 | 98.80 | 3975 | 1.49 | 93.59 | 3838 | 1.40 | 96.31 | 3889 | 1.45 |
| 7 | Irrigation charges. | (Rs.) | | | 2664 | 1.06 | | 5399 | 2.03 | | 6768 | 2.46 | | 5568 | 2.08 |
| 8 | Plant Protection | (Rs.) | | | 3500 | 1.40 | | 4578 | 1.72 | | 4870 | 1.77 | | 452 6 | 1.69 |
| 9 | Incidental charges | (Rs.) | | | 155 | 0.06 | | 208 | 0.08 | | 251 | 0.09 | | 219 | 0.08 |
| 10 | Repairing Charges | (Rs.) | | | 199 | 0.08 | | 25 7 | 0.10 | | 356 | 0.13 | | 301 | 0.11 |
| 11 | Working Capital (1 to 10) | (Rs.) | | | **113588** | 45.29 | | **120455** | 45.29 | | **124131** | 45.20 | | **121003** | 45.27 |
| 12 | Interest on working Capital @ 6% | | | | 6815 | 2.72 | | 7227 | 2.72 | | 744 8 | 2.71 | | 7260 | 2.72 |
| 13 | Depreciation | (Rs.) | | | 1388 | 0.55 | | 1596 | 0.60 | | 1731 | 0.63 | | 1624 | 0.61 |
| 14 | Land Revenue | (Rs.) | | | 175 | 0.07 | | 178 | 0.07 | | 180 | 0.07 | | 178. | 0.07 |
| **15** | **Cost $A_1$ (Items 11 to 14)** | (Rs.) | | | **121966** | 48.63 | | **129457** | 48.68 | | **133491** | 48.61 | | **130066** | 48.66 |
| 16 | Rental Value Leased in land | | | | - | - | | - | - | | - | - | | - | - |

Continue…

| S. N. | Item | Unit | | Small | | | Medium | | | Large | | | Overall | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Input ha$^{-1}$ | Total Cost ha$^{-1}$ | % to Cost 'C$_3$' | Input ha$^{-1}$ | Total Cost ha$^{-1}$ | % to Cost 'C$_3$' | Input ha$^{-1}$ | Total Cost ha$^{-1}$ | % to Cost 'C$_3$' | Input ha$^{-1}$ | Total Cost ha$^{-1}$ | % to Cost 'C$_3$' |
| **17** | **Cost A$_2$ (Items 15 to 16)** | | | | **121966** | 48.63 | | **129457** | 48.68 | | **133491** | 48.61 | | **130066** | 48.66 |
| 18 | Int. on Fix. Cap. @ 10% | | | | 3192.24 | 1.27 | | 3483 | 1.31 | | 3630 | 1.32 | | 3417 | 1.28 |
| **19** | **Cost B$_1$ (Items 15 + 18)** | | | | **125159** | 49.91 | | **132939** | 49.99 | | **137120** | 49.93 | | **133483** | 49.93 |
| 20 | Rental Value of Land | (Rs.) | | | 75903 | 30.27 | | 82517 | 31.03 | | 87008 | 31.68 | | 83496 | 31.23 |
| **21** | **Cost B$_2$ (Items 19 to 20)** | | | | **201062** | 80.17 | | **215456** | 81.02 | | **224128** | 81.62 | | **216979** | 81.17 |
| 22 | Family Human Labour | Male | Days | 92.41 | 18411 | 7.34 | 90.62 | 18256 | 6.86 | 88.60 | 17754 | 6.47 | 90.54 | 18042 | 6.75 |
| | | Female | Days | 56.24 | 8518 | 3.40 | 53.69 | 8055 | 3.03 | 51.76 | 7764 | 2.83 | 53.99 | 7998 | 2.99 |
| **23** | **Cost C$_1$ (Items 19+22)** | (Rs.) | | | **152087** | 60.64 | | **159250** | 59.88 | | **162638** | 59.23 | | **159522** | 59.67 |
| **24** | **Cost C$_2$ (Items 21+22)** | (Rs.) | | | **227990** | 90.91 | | **241767** | 90.91 | | **249646** | 90.91 | | **243018** | 90.91 |
| **25** | **Cost C$_2$* (Items 24)** | | | | **227990** | 90.91 | | **241767** | 90.91 | | **249646** | 90.91 | | **243018** | 90.91 |
| **26** | **10% Cost C$_2$*** | | | | **22799** | 9.09 | | **2417 7** | 9.09 | | **24965** | 9.09 | | **24302** | 9.09 |
| **27** | **Cost C$_3$ (Items 25+26)** | | | | **250789** | 100.00 | | **265943** | 100.00 | | **274611** | 100.00 | | **267320** | 100.00 |
| 28 | Main produce | (Rs.) | | 66.74 | 456469 | | 68.29 | 496171 | | 69.93 | 523126 | | 69.05 | 502047 | |
| **29** | **Per quintal cost of Production** | (Rs.) | | | **3416** | | | **3540** | | | **3570** | | | **3519** | |

**Table 3: Cost, returns and profitability from Turmeric (Rs ha$^{-1}$)**

| S.N. | Particulars | Small | Medium | Large | Overall |
|---|---|---|---|---|---|
| 1 | Main Produce (q ha$^{-1}$) | 67 | 6 9 | 69.93 | 69 |
| 2 | Value of Main produce | 456468.75 | 496171 | 523126 | 502047 |
| 3 | Gross Returns | 456469 | 496171 | 523126 | 502047 |
| 4 | **Cost of Cultivation at** | | | | |
| | Cost $A_1$ | 121966 | 129457 | 133491 | 130066 |
| | Cost $A_2$ | 121966 | 129457 | 133491 | 130066 |
| | Cost $B_1$ | 137120 | 132939 | 137120 | 133483 |
| | Cost $B_2$ | 201062 | 215456 | 224128 | 216979 |
| | Cost $C_1$ | 152088 | 159250 | 162638 | 159522 |
| | Cost $C_2$ | 227990 | 241767 | 249646 | 243018 |
| | Cost $C_3$ | 250789 | 265943 | 274610 | 267320 |
| 5 | **Net Returns at** | | | | |
| | Cost $A_1$ | 334502 | 366714 | 389635 | 371982 |
| | Cost $A_2$ | 334502 | 366714 | 389635 | 371981 |
| | Cost $B_1$ | 319348 | 363231 | 386006 | 368564 |
| | Cost $B_2$ | 255406 | 280714 | 298998 | 285068. |
| | Cost $C_1$ | 304381 | 336921 | 360488 | 342525 |
| | Cost $C_2$ | 228478 | 254404 | 273480 | 259029 |
| | Cost $C_3$ | 205679. | 230228 | 248516 | 234727 |
| 6 | **Benefit-Cost ratio at** | | | | |
| | Cost $A_1$ | 3.74 | 3.83 | 3.92 | 3.86 |
| | Cost $A_2$ | 3.74 | 3.83 | 3.92 | 3.86 |
| | Cost $B_1$ | 3.33 | 3.73 | 3.82 | 3.76 |
| | Cost $B_2$ | 2.27 | 2.30 | 2.33 | 2.31 |
| | Cost $C_1$ | 3.00 | 3.12 | 3.22 | 3.15 |
| | Cost $C_2$ | 2.00 | 2.05 | 2.10 | 2.07 |
| | Cost $C_3$ | 1.82 | 1.87 | 1.90 | 1.88 |

1.82, 1.87 and 1.90, respectively. The overall benefit-cost ratio was 1.88. The results of economics of turmeric production in Satara district of Maharashtra state was observed by Kamble, *et al*. (2017).

## CONCLUSION

The gross cropped area was highest in large size group i.e. 7.04 ha. followed by medium size group (4.07 ha) and small size group (2.17 ha), respectively.

The share of area under turmeric in small, medium and large size of land holding group and at overall level in gross cropped area was 14.75, 17.20, 17.05 and 17.25 per cent, respectively.

Among the entire crops soybean dominated the cropping pattern in *kharif* and wheat in *Rabi*.Per hectare cost '$A_1$'was highest in large farmer i.e. Rs. 133491 followed by medium size group (Rs. 129457) and small size group (121966) respectively and at overall level it was Rs.130066.

Total cost of cultivation of turmeric ha$^{-1}$ i.e. cost '$C_3$' was highest in the large size group i.e. Rs. 274611 followed by medium size group (Rs. 265943) and small size group (Rs. 250789), respectively and at overall level it was Rs. 267320.

The average yield and gross returns per hectare increased with the increase in size of farms.The benefit cost ratio of Turmeric cultivation at cost '$C_3$' was higher in large size group i.e. 1.90, followed by medium size group i.e. 1.87 and small size group i.e. 1.82 and at overall level it was 1.88. This indicates that, cultivation of turmeric crop was economically profitable.

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Received on 25 May, 2021

PKV Res. J. Vol. 45(1), January, 2021

# Design and Development of Media Mixture Machine for Horticultural Crop Nursery

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**ABSTRACT**

Preparation of media mixture is important operation in horticultural nursery. Traditionally media was mixed and filled manually in poly bags, it requires more labour and time. The labours were not available in time and hinder the nursery raising process. The media were being mixed by spade preferably by men labourers. Then women workers were filling the media mixture in poly bags in sitting posture. It was not only a tedious job with poor output, but also a laborious work. The manually mixed media does not get mixed properly and may affect the growth of seedling. To overcome above mention problem, the media mixture machine was designed and developed for horticultural crop nursery. The developed media mixture machine was suitable for small scale horticulture nursery. Its consists of hopper, pulverizing drum, sieve, mixing drum, metering mechanism, electric motor and safety guard. An electric motor of 2 hp single phase rated power was selected as the power source for operating the media mixture machine. The media obtained from machine was uniform and properly mixed which was required for better establishment of nursery sapling.It was found that bulk density of media mixture decreases whereas particle density and total porosity of media mixtureincreases after passing through pulverizing and mixing drum of developed machine. The size of media obtained was minimum 1.97 mm at 140 kg $h^{-1}$ feed rate. The thoroughly mixed media mixture was obtained from developed media mixture machine. The degree of metering of developed media mixture machine varies from 1.4 per cent to 1.57 percent with different operating conditions. The power required to operate media mixture machine was in range of 0.62 to 1.06 kW with different operating conditions.

In India, the total area under horticultural crop is 24.9 M ha with production of 295.2 MT. India is the second largest producer of fruits and vegetables in the world and is the leader in several horticultural crops, namely mango, banana, cashew-nuts, arecanut, pomegranate, sapota, guava. etc.(Anonymous, 2017). Konkan is the leading region in producing a large variety of fruits comparing to other regions in Maharashtra. In Konkan, area under horticulture crop is 317955 ha with annual production of 755800 MT (Anonymous, 2018).There are nearly two hundred fifty horticulture nurseries present in Konkan region. Annually for preparing 1,00,000 grafts nurseryman need 200 tonnes of soil (Anonymous, 2015). Nursery is consequently the basic need of horticulture.Many operations are involved in seedling production which include selection of horticultural crop followed by preparation of media mixture for the selected crop. A good quality of media mixture for nursery operation is free from added organic fertilizer with its pH ranging from 5.5–6.5 (Krishnan *et al.,* 2014).Traditionally media is mixed and filled in poly bags by manually. The media are being mixed by spade preferably by men labourers. Then women workers are filling the media mixture in poly bags in sitting posture. In the existing method of media preparation in the horticultural nurseries, both men and women labourers are essentially required for mixing and filling the media. It is not only a tedious job with poor output, but also a laborious work. The manually mixed potting does not get mixed properly and may affect the growth of seedling. It also costs more for completing the task in time. In manual method, only 300-350 bags of 500 g can be filled in a day which costs 1140 per 1000 bags (Kasten, *et al*, 2011, Essegbemon *et al.* 2014). The present operation, which is carried out manually using spade for mixing, pulverizing is usually done in unscientific manner and there is no control to avoid contamination in manual handling. Moreover, it is tedious in the bending posture during the operation with spade.

The media siever are commercially available, but complete system for pulverizing, sieving, mixing and metering desired quantity of media are not available at present. All the facilities should be available in one

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machine. There is need to be mechanised and improved preparation and filling of media mixture for nursery raising. The horticultural plants seedling need media of 500 to 2000 g depending upon crop / variety. The most of the nursery growers are small and medium, growing one lakh to two lakhs grafts / sapling annually. Hence to overcome the above said problems and provide solutions, development of media mixture machine suitable for small and medium size nursery growers of horticultural fruit crops.

## MATERIAL AND METHODS

### Design

The power operated media mixture machine was design, developed based on the following assumptions and considerations for design of machine. 1. Particle size requirement Effective size of particle of media mixture should in range 0.5 to 6 mm. (Handreck K.A, 1983). 2. Capacity of media mixture machine 3. Fine sieving and uniform mixing of media mixture for proper growth of seedling is required. 4. Power requirement of media mixture machine. Volume of mixing chamber calculated by following formula,

$$v = \pi \frac{r2}{2} h$$

Where,

v = Volume of mixing chamber, $m^3$,r = Radius of the circular base (0.19 m)

h = Length of the cylinder (0.56 m).

### Torque of mixing drum shaft

According to (Khurmi and Gupta, 2007) shafts may be designed on the basis rigidity and strength.

$$T = F \times l$$

Where,

T = Torque, (N.m),

l = Length of paddle agitator, mw

F = Force acting on the media, N

$$W = F + mg$$

Where,

w = Weight of media, (kg)

m = Mass of the media, (kg) and

g = Acceleration due to gravity, ($m/s^2$),

$$m = F = \text{density} \times \text{volume}$$

Power requirement of mixing media in mixing chamber is,

$$P = \frac{2\pi NT}{60}$$

Where,

P = Power,

WN = Revolution per minute, (Assume mixing drum speed 100 rpm, (Joshi, 1976).

T = Torque, Nm (32.7 Nm)

Total power requirement = Power for pulverizing + Power for mixing + Power for sieving

### Design of pulverizing drum

Pulverizing drum consist of lower concave drum, upper drum attached to hopper and beater shaft having eight number of MS flat attached to the main rotating shaft.

### Pulverizing cylinder diameter

$$D_c = \frac{V \times 100}{\pi + x\ N_c}$$

Where,

$D_c$ = Diameter of pulverizing drum, mm

V = Peripheral velocity of pulverizing drum, m/s

$N_c$ = Speed of pulverizing drum, rpm

Generally, the length of cylinder taken, 1.5 times of diameter of cylinder. (1.5:1)

$$\text{Length of pulverizing cylinder (L)} = 1.5 \times Dc$$

Where,

L = Length of pulverizing cylinder, mm,

$D_c$ = Diameter of pulverizing cylinder, mm

### Design of Hopper

The design of feed hopper was derived using following equation: (Patil and Dhande, 2011).The capacity of hopper was calculated by using following formula.

$$Q = V \times \rho$$

Where,

Q = Capacity of hopper, kg

V = Volume of the hopper, $m^3$

ρ = Density of soil and FYM, $kg/m^3$.

The volume of hopper was calculated by using following formula,

$$\text{Value (V)} = A \times L_B$$

Where,

V = Volume of the hopper $m^3$,

A = Cross sectional area, $m^2$

$L_B$ = Length of hopper, m

Cross sectional area of hopper was calculated by using following formula

$$\text{Cross Sectional Area, } A = h\,(B + h \cot \alpha)$$

Where,

A = Cross sectional area, $m^2$

h = Height of hopper, m

B = Breadth of hopper,

má = Angle of repose, °

**Beater cylinder shaft**

The diameter of the beater cylinder shaft was determined using following design equations: (Sharma and Mukesh, 2010)

$$T = \left(\frac{60P}{2\pi N_{max}}\right) \quad \text{and} \quad T = \left(\frac{\pi}{(16)}\right) \tau d^3_s$$

Where,

P = Maximum power to be transmitted, W

$d_s$ = Diameter of MS shaft, mm

T = Torque to be transmitted through shaft, kg

$\pi m N_{max}$ = Maximum rotational speed of shaft, rpm

$\tau$ = Permissible shear stress of MS =42 $N/mm^2$

**Length and number of beaters**

The number of beaters on the cylinder was calculated by using following formula. (Sharma and Mukesh, 2010),

$$\text{Curdumference} = \pi D \text{ No. of beater } \frac{\pi D}{\text{Distance between beater}}$$

**Concave of pulverizing unit**

The length and diameter of concave were 560 and 370 mm, respectively and it is fabricated using 8 mm diameter M.S bars.

**Design of sieve**

The sieve is used for separating large size stone in the media**.** It is fitted on the sides of main frame i.e upper part and the lower concave of pulverizing drum. The sieve had circular openings.

**Sieve shaker eccentricity and speed**

Ismail (1986) recommended that optimum stroke length of small sieve, $l_s$ as 30 mm. Hence, sieve shaker eccentricity is calculated by using $e_s \frac{t_s}{2} = 30/2$

Where,

$l_s$ = Stroke length, mm

$e_s$ = Eccentricity of sieve, mm

James and Sullivan, (2013), had recommended the optimum frequency of stroke, ($n_s$) as 475 strokes / min for sieving. Hence, speed of sieving unit shaft is calculated using

$$N_e = \frac{n_s}{2}$$

Where,

$n_s$ = Frequency of stroke/min

$N_e$ = Speed of sieving unit, rpm

**Design of sieve shaft**

The design of sieve shaft based on consideration of subjected to combined effect of torsion loading and bending. Hence, according to the maximum shear stress theory (Khurmi and Gupta 2007), the equivalent twisting moment of the shaft is given by,

$$T_{et} = T_{et} = \sqrt{(K_m \times M_{bt})^2 + (K_t \times T_t)^2} \text{ Also Tet} = \frac{\pi \times d_t^3 \times \tau t}{16}$$

Where,

$T_{et}$ = equivalent twisting moment,

N-m$M_{bt}$ = bending moment, N-m

$T_t$ = torque to be transmitted, N-m

$\tau_t$ = maximum shear stress of the shaft material, $N/m^2$

$K_m$ = combined shock and impact factors for bending moment

$d_t$ = diameter of main shaft, m.

$K_t$ = combined shock and impact factors for twisting moment,

The torque to be transmitted for shaft to operate shaking mechanism is given as follows,

$$Tt = \frac{Pt \times 6000}{2 \times \pi \times N_t}$$

Where,

$P_t$ = available power, kW
$N_t$ = shaft speed, rpm; and
$T_t$ = torque to be transmitted, N-m

Let the pulley of diameter 280 mm be mounted on the sieving shaft at a distance of 100 mm from the center of bearing, the tangential load working on the pulley will be,

$$Ftt = \frac{2 \times T_t}{D_t}$$

Where,

$F_{tt}$ = tangential load, N and
$D_t$ = Diameter of pulley, m.and bending moment,

$$M_{bt} = F_{tt} \times x_t$$

Where,

$x_t$ = Bending moment constant,

**Design of mixing drum**

The diameter and the length of mixing drum are 380 mm and 560 mm, respectively. (Mandhar *et al.,* 2004).

**Design of mixing drum shaft**

The diameter of the mixing drum shaft was determined using following design equations: (Sharma and Mukesh, 2010)

$$T = \frac{\pi}{16} \tau d^3_s$$

Where,

$\pi$ = Maximum power to be transmitted,
$\tau d_s$ = Diameter of MS shaft, mm
T = Torque to be transmitted through shaft, kg-m,
$N_{max}$ = Maximum rotational speed of shaft, rpm
Ô = Permissible shear stress of MS = 42 N/mm$^2$

**Design of pulverizing shaft, mixing shaft and sieving shaft**

The beater shaft, sieving shaft and mixing unit shaft also subjected to torsion loading and bending moment.

**Development of metering mechanism**

Media mixture is required for nursery operations.

**Basic principle of metering mechanism:** The metering mechanism is a device to measure the required quantity media by weight basis.

**Weighing container:** The soil sample is placed in a container. The container is made up of GI (Galvanised Iron) sheet 18 SWG (Standard Wire Gauge).

**Collecting container:** The outlet soil sample is collected in the collecting container. It was not fixed at the bottom end because the collecting container has to remove from the position to fill the bags.

**Balancing bar:** Balancing bar is hinged on fulcrum point which is perpendicular to the frame at the bottom..

**Principle of operation of media mixture machine with metering mechanism**

The soil was collected free from the big clods. The soil was fed continuously, into the pulverizing cylinder. The pulverizing cylinder consist of beaters rigidly fixed on the shaft. The fixed beaters were used to break the soil clod into smaller particles. The smaller particle size of soil passed through concave fall onto the sieve. The opening of the sieve was 5 mm. The soil particle above 5 mm was retained on the sieve. The smaller particles which were passed through the sieve was fall on the retention pan and then goes to the mixing drum. In mixing drum, all ingredients are mixed properly for the homogenous mixture. The homogenous mixture is required for the proper growth seedling / plant. The mixture came out of the outlet.


**Fig: Developed media mixture machine for horticultural crop nursery**

**Table.Specifications of developed media mixture machine for horticultural crop nursery.**

| S.N. | Parameter | Specification |
|---|---|---|
| **A)** | **Pulverizing drum** | |
| 1 | Diameter, mm | 370 |
| 2 | Length, mm | 560 |
| 3 | Thickness (M.S flat sheet), mm | 3 |
| 4 | Concave clearance, mm | 8 |
| 5 | No. of beater | 8 |
| | Length of beater, mm | 120 |
| | Width of beater, mm | 40 |
| | Thickness of beater, mm | 8 |
| **B)** | **Shaking sieve** | |
| 1 | Length, mm | 580 |
| 2 | Width, mm | 460 |
| 3 | Height, mm | 50 |
| **C)** | **Mixing drum** | |
| 1 | Length of drum, mm | 560 |
| 2 | Diameter of drum, mm | 380 |
| 3 | Paddle type agitator | |
| | No. of paddles, | 8 |
| | Height of paddle, mm | 150 |
| | Length of paddle, mm | 100 |
| | Width of paddle, mm | 70 |
| **D)** | **Diameter of shafts** | |
| 1 | Pulverizing shaft, mm | 25 |
| 2 | Mixing shaft , mm | 25 |
| **3** | **Sieving shaft, mm** | **20** |
| **E)** | **Main frame** | |
| 1 | Height, mm | 970 |
| 2 | Length, mm | 920 |
| 3 | Width, mm | 580 |
| **G)** | **Overall dimensions of machine** | |
| 1 | Height, mm | 970 |
| 2 | Length, mm | 920 |
| 3 | Width, mm | 760 |

## RESULTS AND DISCUSION

The performance evaluation of developed media mixture machine for horticultural crop nursery was carried out. The known quantity of soil and FYM clod was fed in pulverizing drum at constant rate for ten minutes. The media mixture was collected at outlet and measured, for each experiment three replications were taken. The output capacity of machine was determined. The particle size of media at outlet, the degree of mixing, degree of metering and power requirement of machine were determined by using standard procedure. Initially, the physical properties of media was determined by using standard procedure. The four independent and five dependent parameter like feed rate 120 kg $h^{-1}$, 140 kg $h^{-1}$ and 160 kg $h^{-1}$, pulverizing drum speed 250, 350 and 450 rpm, mixing drum speed 50, 100 and 150 rpm and frequency of sieve 400, 500 and 600 No. of strokes $min^{-1}$ for response parameter viz. capacity of machine, kg $h^{-1}$, particle size of media at outlet, mm, degree of metering, per cent, degree of mixing, per cent and power required, kW were considered for performance evaluation. The average value of bulk density of soil and FYM before operation was found to be 1.16 g/cc and 0.465 g/cc and respectively. Similarly, the bulk density of media mixture obtain at outlet of media mixture machine is 0.941 g/cc. The average porosity of soil before operation was found to be 47.7 per cent whereas, for media 54.73 per cebnt after operation. The average particle density was found to be 2.22 g/cc before operation (soil) and 2.43 g/cc after operation (media).

Capacity of machine varied from 30 kg/h at feed rate 140 kg $h^{-1}$, pulverizing drum speed 250 rpm, mixing drum speed 50 rpm and frequency of sieve 500 No. of strokes $min^{-1}$ to 128 kg $h^{-1}$ at feed rate 160 kg $h^{-1}$, pulverizing drum speed 450 rpm, mixing drum speed 100 rpm and frequency of sieve 500 No. of strokes $min^{-1}$ with the mean capacity of 75.8 ± 7.2 kg $h^{-1}$ during operation of media mixture machine at different operating conditions.Particle size of media at outlet varied from 1.25 mm at feed rate 140 kg $h^{-1}$, pulverizing drum speed 450 rpm, mixing drum speed 150 rpm and frequency of sieve 500 No. of strokes $min^{-1}$ to 3.2 mm at feed rate 140 kg $h^{-1}$, pulverizing drum speed 250 rpm, mixing drum speed 100 rpm and frequency of sieve 500 No. of strokes $min^{-1}$ with mean particlesize of 2.19 ± 0.10 mm during the operation of media mixture machine at different operating condition. The degree of mixing varies from 76.89 per cent at feed rate 160 kg $h^{-1}$, pulverizing drum speed 350 rpm, mixing drum speed 150 rpm and frequency of sieve 500 No. of strokes $min^{-1}$ to

94.04 per cent at feed rate 140 kg/h, pulverizing drum speed 350 rpm, mixing drum speed 100 rpm and frequency of sieve 500 strokes $min^{-1}$ with mean degree of mixing 87.51 ± 1.04 during the operation of media mixture machine at different operating conditions. The degree of metering varied from 1.4 per cent at feed rate 140 kg $h^{-1}$, pulverizing drum speed 350 rpm, mixing drum speed 100 rpm and frequency of sieve 500 No. of strokes $min^{-1}$ to 1.57 per cent at feed rate 140 kg $h^{-1}$, pulverizing drum speed 250 rpm, mixing drum speed 100 rpm and frequency of sieve 600 No. of strokes $min^{-1}$ with mean degree of metering 1.46 ± 0.02 during entire operation of media mixture machine at different operating conditions.The voltage and current required for operation was measured with the help of tong tester. The power of machine varies from 0.624 kW at feed rate 120 kg $h^{-1}$, pulverizing drum speed 250 rpm, mixing drum speed 100 rpm and frequency of sieve 500 No. of strokes $min^{-1}$ to 1.069 kW at feed rate 160 kg $h^{-1}$, pulverizing drum speed 450 rpm, mixing drum speed 100 rpm and frequency of sieve 600 No. of strokes $min^{-1}$ with mean 0.84 ± 0.03 during entire operation of media mixture machine at different speed of operating conditions.

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Received on 25 February, 2021

PKV Res. J. Vol. 45(1), January, 2021

# Performance Evaluation of Tractor Operated Sprayer and Spray Gun

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## ABSTRACT

The Tractor operated sprayer was developed in the Department of Farm Power and Machinery, Dr. PDKV, Akola and the trials were carried out in the field of Western block, Sorghum Research Unit, Dr. PDKV, Akola. The PTO of tractor is the major source to operate HTP pump, belt, pulleys, etc. The performance evaluation of tractor operated sprayer and spray gun were evaluated in field and orchard crop in different fields at an average speed of 3.43 km/h and 1.89 km $h^{-1}$ for spraying with boom sprayer for field crop and guns spraying for lemon plant. Average application rate of both the spraying i.e. boom and guns spraying was found to be 421.67 and 272.21 liter $ha^{-1}$, respectively. Average effective field capacity of the machine was found to be1.70 and 0.89 ha $h^{-1}$, respectively. The average cost of operation and fuel consumption was observed as 317 Rs $h^{-1}$. Power requirement for both spraying was found 1.5 hp.


Spraying is one of the most important farming operations. Spraying of horticultural crop as well as field crop requires considerable amount of labour, drudgery and time. Due to non-availability of proper design and well calibrated sprayers the spraying operation hampers with poor quality of the operation. Small and marginal land holdings, cropping patterns, poor road structures to reach to the farms and purchase capacity of the farmers are the factors which reduced the use of the boom sprayers. By utilizing the traditional knapsack sprayers they cannot achieve the timeliness in the operations due to labour shortage in peak seasons, which ultimately affects the quality and yield of the crops. Hence the present study was aimed to develop tractor operated field and orchard crop sprayer suitable for small and marginal land holders as far as to meet the agro technical requirements of various crops spraying operations and with the reasonable price.

The mechanization of agriculture not only reduces the overall cost of production but also increases the total agricultural yield. Through mechanized farming, many countries in the world are reaching the upper limits of their cultivable land. The increasing use of agricultural machinery, equipment and fertilizers coupled with better irrigation facilities, together revolutionizes the agricultural sector. Spraying operation is one of the most important phases during the crop cultivation practices. At present traditional knapsack sprayers are still utilized due to non-availability of well design and reasonable cost boom sprayers. Some attempt was made by the local manufacturers but they are not well designed, not calibrated, and not easy in the adjustment hence adoptability of such sprayers in the regions are less.

By introduction of well-designed tractor operated field and orchard crop sprayer, spraying will has become cheaper and easier than ever. Spraying through machine is not only saves the time but also reduces the quantity of waste to a great extent. Ease in the operation, easy to adjust the height on the target crop, proper application rate, multiple utility and low cost makes more adoptable among the farmers which ultimately effect quality produce, increase in crop production with reasonable cost.

## MATERIAL AND METHODS

Evaluated the field performance of horizontal boom for weedicides application and spraying of horticulture crop through gun and vertical spray boom by boom sprayer. Following parameters were studied wile field evaluation of sprayer.

1) Speed of operation
2) Effective field capacity
3) Theoretical field capacity
4) Field efficiency
5) Fuel consumption
6) Easy of operation

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**Speed of operation**

For calculating travelling speed two poles 30 m apart was placed approximately in middle of the test run. On the opposite side also two poles were placed in similar position, 30m apart so that four poles forms corners of rectangle, parallel on long side of the plot. The speed was calculated from the time required for machine to travel the distance (30 m) between two poles. Average of such reading was taken to calculate the travelling speed of tractor operated sprayer. The forward speed of operation was calculated by observing the distance traveled and time taken and calculated by following formula (Mehta *et al.,* 2005).

$$S = \frac{L}{t} \quad \text{..... (1)}$$

Where,

S = forward speed of machine, m/s
L = distance travelled, m
t = time taken, s

**Theoretical field capacity**

For calculating the theoretical filed capacity, working width and travelling speed has been taken in to consideration. It is always greater than the actual field capacity. Theoretical field capacity is calculated by using following formula (Mehta, 2005).

$$T.F.C. = \frac{S \times W}{10} \quad \text{..... (2)}$$

Where,

T.F.C.= theoretical field capacity, (ha/h)
W = theoretical width of Implement, (m)
S = speed of operation, (km/h)

**Effective field capacity**

For calculating effective field capacity, the time consumed for actual work and lost for other activities such as turning and filling the tank of spray. Effective field capacity was calculated by following formula (Mehta, 2005).

$$E.F.C. = \frac{A}{T_P + T_1} \quad \text{..... (3)}$$

Where,

E.F.C. = effective field capacity (ha/h)
A = area (ha)
$T_p$ = productive time (h)
$T_1$ = non-productive time, (h)

**Field efficiency**

Field efficiency will be calculated by taking ratio of effective field capacity to theoretical field capacity. It is always expressed in percentage.

It was calculated by following formula (Mehta et *al.,* 2005).

$$\text{Field efficiency (\%)} = \frac{E.F.C.}{T.F.C.} \times 100 \quad \text{..... (4)}$$

Where,

E.F.C. = effective field capacity (ha/h)
T.F.C. = theoretical field capacity (ha/h)

**Fuel consumption**

The fuel consumption of is determined by topping up the fuel tank before the start of the test and after completion of test duration.

**Cost Economics of Tractor Operated sprayer**

The cost of operation of tractor operated tractor operated field and orchard crop sprayer is the addition of cost of operation of tractor and cost of operation of machine. The cost operation was calculated using the standard procedure. The total cost of operation per hour consists of fixed cost and operating cost as per IS: 9164(1979)

**A. Fixed cost includes**

1) Depreciation
2) Interest
3) Housing
4) Insurance
5) Taxes

**B. Operating cost includes**

1) Fuel cost
2) Lubricant cost

3) Repair and maintenance cost
4) Wages

C. Total cost (A + B)

**A. Fixed cost per hour**

The fixed cost is the ownership costs are independent of used and often called as fixed cost. It was calculated by taking total of following costs.

**1) Depreciation**

This cost reflects the reduction in value of machine with used (were) and time (obsolescence). While actual depreciation would depends upon the sale price of the machine after it's used, on the basis of the different computational methods depreciation can be estimated. It is loss of value of tractor and sprayer with passing of time and was calculated by following formula.

$$D = \frac{P - X}{L \times H} \quad \text{..... (5)}$$

Where,

D = Depreciation per hour
P = Purchase price or capital investment
S = Salvage value which is 10% of purchase price
L = Total life of tractor and implement in years
h = No. of working hours of tractor and implement year$^{-1}$

**2) Interest**

It was calculated on the average investment of the tractor and sprayer by taking into consideration the value of the tractor and sprayer first and last year and was calculated by following formula.

$$I = \frac{P + S}{2} \times \frac{R}{100} \quad \text{.....(6)}$$

Where,

I = Interest to be paid per hour
R = Rate of interest per year (taken as 12%)

**3) Housing**

It was calculated on the basis of the prevailing rates of the market but roughly taken as 1% of initial cost of tractor and implement per year.

$$H = \frac{P}{h} \times \frac{1}{100} \quad \text{..... (7)}$$

Where,

H = Housing cost per hour (taken 1% of purchase price)

**4) Insurance**

For tractor, it is taken as 1% of purchase price and for implement insurance charges were taken as nil.

**5) Taxes**

For tractor, it is taken as 1% of purchase price and for machine taxes were taken as nil.

**B. Variable cost**

The cost for operation varies directly with use and is referred to as variable cost. It includes total of following costs.

**1) Fuel cost**

It includes actual cost paid for fuel during operation of tractor. For machine fuel charges were taken as nil.

**2) Lubricants cost**

For tractor, it is taken as 10% of fuel cost and for machine it was taken as Nil.

**3) Repair and maintenance cost per hour**

Generally it varies between 5 to 10% of the initial cost per year. Here, it was considered 8% of initial cost and calculated as.

$$\text{R \& M cost per hour} = \frac{8 \times P}{100 \times b} \quad \text{..... (8)}$$

**4.5.2 Determination of cost of operation**

Total cost of operation of developed sprayer in Rs/ha was calculated by using following formula

$$\text{Cost of operation (Rs/ha)} = \frac{\text{cost of operation of implement (Rs/ha)}}{\text{Effective field capacity of implement (ha/h)}}$$

**Performance Evaluation of Tractor Drawn Sprayer**

The field trials of newly developed sprayer were taken at Western Block, Dr. PDKV, Akola. The performance and evaluation trial of machine has been carried out as per testing procedure mentioned in Indian Standard. Machine performance was evaluated in weed infected field and orchard crop spray. The performance results of this trials ware as given below

**Field Performance of Sprayer in Weed Infested Field**

In weed infested flied weedicides sprayed by using tractor drawn sprayer. The details of the performance result of machine are presented in Table1. Machine operational parameters and results observed during the test were as discussed below.

**Width of Operation**

Width of spraying effects effective field capacity of sprayer.Theaverage width was observed in the range 6 to 6.02 m whereas the average width of operation was observed 5.97m. As the boom nozzles are placed on 6 m swath width the average swath width observed 5.97 m. The variation in the swath width might be due to effect of wind during the field trials.

**Speed of Operation**

The speed of operation was observed in the range 3.06 to3.48 km $h^{-1}$ whereas the average speed of operation was observed 3.43 km $h^{-1}$. It was observed that the working on these speeds was convenient for field operations without any obstacle.

**Actual Field Capacity**

The field efficiency of the machine depends upon size of plot, adjustment of the machine, swath width, speed of machine and upon the skill of operator. The actual field capacity of the machine was observed in the range of 1.71 to 1.81 ha $h^{-1}$. The average effective field capacity of sprayer was found 1.70 ha $h^{-1}$.

**Theoretical Field Capacity**

The theoretical field capacity of the sprayer for weedicides application in the field was in the range of 2.08 to 2.19 ha/h. whereas the average theoretical field capacity of the sprayer was found 2.03 ha $h^{-1}$.

**Field Efficiency**

The field efficiency of the machine depends upon size of plot, adjustment of the machine and depends

**Table 1 Performance of boom sprayer for weedicides application**

Temperature (42 $^0$C), Relative humidity (12%), Wind speed (0.43 km $hr^{-1}$)

| S. N. | Particulars | Trial 1 | Trial 2 | Trial 3 | Trial 4 | Average |
|---|---|---|---|---|---|---|
| 1 | Length of plot, m | 80 | 80 | 80 | 80 | 80 |
| 2 | Width of plot, m | 50 | 50 | 50 | 50 | 50 |
| 3 | Area,$m^2$ | 4000 | 4000 | 4000 | 4000 | 4000 |
| 4 | Total time, min | 13.8 | 15 | 13.8 | 13.2 | 13.9 |
| 5 | Effective width of sprayer, m | 6 | 5.9 | 5.8 | 6.2 | 5.97 |
| 6 | Total time required to complete one hector area, h | 0.57 | 0.62 | 0.57 | 0.55 | 0.57 |
| 7 | Speed of operation, km/h | 3.48 | 3.27 | 3.37 | 3.6 | 3.43 |
| 8 | Theoretical field capacity, ha/hr | 2.08 | 1.92 | 1.95 | 2.19 | 2.03 |
| 9 | Actual field capacity, ha/h | 1.71 | 1.62 | 1.69 | 1.81 | 1.70 |
| 10 | Field efficiency, % | 82.21 | 84.37 | 86.67 | 82.64 | 83.97 |
| 11 | Fuel consumption, lit/ha | 2 | 1.85 | 1.90 | 1.92 | 1.91 |
| 12 | Total sprayer output ,lit/min | 14.45 | 14.30 | 14.38 | 14.35 | 14.37 |
| 13 | Spray application rate (lit/ha), for various speed and avg. discharge. | 415.22 | 444.79 | 41.32 | 385.32 | 421.67 |
| 14 | Cost of operation, Rs/h | 321 | 313 | 316 | 318 | 317 |

upon the skilled operator. The field efficiency of the machine was in the range of 82.21 to 82.64 %.The average field efficiency of sprayer was found 83.97%.

**Spray application rate**

The application rate of the boom sprayer was observed in the range of 385.32 to 415.22 lit/ha. The average spray application rate was observed as 421.67 lit/ ha. For this application rate the sprayer is categorized inmedium volume sprayer on the basis of volume of liquid spray (IS: 8480-1996.)

**Fuel consumption**

The fuel consumption for the boom sprayer application was in the range of 1.92 to 2 lit/ha. The average fuel consumption rate was observed as 1.91 lit/ha.

**Field performance of spray gun in orchard field**

For spraying operation in lemon orchard the boom was set for vertical spraying operation on the target as shown in plate 1. It was observed that the plant canopy of the lemon orchard plants was not suitable to move the vertical spray boom in the field plate 2.

**Plate 1 : Performance of boom in the field spraying with vertical boom sprayer.**

**Plate 2 : View of lemon orchard .**

To overcome from this situation the spray gun was utilized to spray the liquid as shown in plate 3. It was observed that the spray guns of the desired rate can apply the spray liquid easily on the orchard crops. The details of the results obtained of the same prototype sprayer with utilizing the spray guns were discussed as given below.

**Plate 3 Performance Gun sprayer in the field.**

**Width of operation**

Width of sparing effects on effective field capacity of sprayer.Theaverage width was observed in the range 6 to 6 mwhereas the average width of operation was observed 6 m. As the gun nozzles are covered the on 6m width the average swath weed observed 6m. The variation in the swath width might due to effect of wind during the field trials.

**Speed of operation**

The speed of operation was observed in the range1.82 to 1.91km/h whereas the average speed of operation was observed 1.89 km/h. It was observed that the working on these speeds was convenient for field operations without any obstacle.

**Actual field capacity**

The field efficiency of the machine depends upon size of plot, adjustment of the machine, swath width, and speeds of machine and depends upon the skilled operator. The actual field capacity of the machine was observed in the range of 0.84 to 0.98 ha/h. The average Actual field capacity sprayer was found 0.89 ha/h.

**Theoretical field capacity**

The theoretical field capacity of the sprayer for weedicides application in the field was in the range of 1.05

**Table 2. Performance results of tractor operated sprayer by utilizing spray guns for Lemon orchard crop.**

Temperature ($38^0$C), Relative humidity (13%), Wind speed (0.39 km $h^{-1}$)

| S.N. | Particulars | Trial 1 | Trial 2 | Trial 3 | Trial 4 | Average |
|---|---|---|---|---|---|---|
| 1 | Row spacing, m | 6 | 6 | 6 | 6 | 6 |
| 2 | Length of plot, m | 100 | 80 | 70 | 90 | 85 |
| 3 | Width of plot, m | 100 | 50 | 55 | 60 | 67 |
| 4 | Area,$m^2$ | 10000 | 4000 | 3850 | 5400 | 5813 |
| 6 | Total time required to complete one hector area, h | 0.70 | 0.28 | 0.27 | 0.33 | 0.39 |
| 7 | Speed of operation, km $h^{-1}$ | 1.97 | 1.86 | 1.82 | 1.92 | 1.89 |
| 8 | Theoretical field capacity, ha $h^{-1}$ | 1.18 | 1.10 | 1.05 | 1.25 | 1.14 |
| 9 | Actual field capacity, ha $h^{-1}$ | 0.91 | 0.85 | 0.84 | 0.98 | 0.89 |
| 10 | Field efficiency, % | 77.11 | 77.92 | 80.10 | 78.48 | 78.40 |
| 11 | Fuel consumption, lit $ha^{-1}$ | 1.95 | 1.89 | 1.90 | 1.92 | 1.91 |
| 12 | Total gun output, lit $min^{-1}$ | 5.140 | 5.152 | 5.146 | 5.150 | 5.147 |
| 13 | Spray application rate (l $ha^{-1}$), for various speed and avg. discharge. | 261.26 | 276.72 | 282.80 | 268.07 | 272.21 |
| 14 | Cost of operation, Rs $hr^{-1}$ | 340 | 335 | 330 | 335 | 335 |
| 15 | Repair and maintains | Nil | Nil | Nil | Nil | Nil |

to 1.25 ha $h^{-1}$. whereas the average theoretical field capacity sprayer was found 1.14 ha $h^{-1}$.

**Field efficiency**

The field efficiency of the machine depends upon size of plot, adjustment of the machine and depends upon the skilled operator. The field efficiency of the machine was in the range of 77.11 to 80.10 per cent. The average field efficiency of sprayer was found 78.40 per cent.

**Spray application rate**

The application rate of the sprayer by spray guns was observed in the range of 261.26 to 282.80 lit $ha^{-1}$.The average spray application rate was observed as 272.21 lit $ha^{-1}$. The received application rate is categories the sprayer on the basis of volume of spray liquid from this the prototype boom sprayer comes under the category medium volume sprayer (Karale *et. al.*, 2014).

**Fuel consumption**

The fuel consumption for the sprayer with spray guns was in the range of 1.89 to 1.95 lit $ha^{-1}$. The average fuel consumption rate was observed as 1.91 lit $ha^{-1}$.

**Economics of spraying operation in field & orchard crops**

The cost of tractor operated field and orchard crop sprayer was determined as per the method specification in IS: 9164-1979. It was observed that the average cost of operation for a prototype spryer with boom attachments was Rs. 317 $ha^{-1}$ during the weedicides application in the field. The same prototype was utilized for lemon orchards with spray guns for applications of the pesticides and the average cost of operation was Rs.335 $ha^{-1}$. It was also observed that the sprayer with guns application requires two additional labours to perform the operation and where the boom cannot work properly due to the agro technical requirements of the crops.

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Received on 17 May, 2021

## Particulars about PKV Research Journal as per Press and Regulation of Book Act (Clause 8)

## FORM IV

| | | | |
|---|---|---|---|
| 1. | Place of Publication | : | Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola |
| 2. | Periodicity of Publication | : | Six monthly |
| 3. | Printer's Name | : | Mr. Mohan G. Thakre |
| 4. | Nationality | : | Indian |
| 5. | Address | : | Tanvi Graphics,<br>Ranpise Nagar, Akola |
| 6. | Publisher's Name | : | Dr. V. K. Kharche |
| 7. | Nationality | : | Indian |
| 8. | Address | : | Director of Research, Dr. PDKV,<br>P.O. Krishi Nagar, Akola |
| 9. | Editor-in-Chief | : | Dr. V. K. Kharche |
| 10. | Nationality | : | Indian |
| 11. | Address | : | Editor-in-Chief<br>Dr. PDKV, P.O. Krishi Nagar,<br>Akola - 444 104 (Maharashtra) |
| 12. | Owner's Name | : | Dr. Panjabrao Deshmukh Krishi<br>Vidyapeeth, Akola |

I, V. K. Kharche declare that the particulars given above are true to the best of my knowledge and belief.

Date : June, 2021

**Dr. V. K. Kharche**
Publisher

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Published by Dr. V. K. Kharche, Director of Research, Dr. PDKV, Akola for and on behalf of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India in 2021 and Printed by him at Tanvi Graphics, Ranpise Nagar, Akola

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