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Influence of irrigation scheduling and weed management practices on growth and yield of Fenugreek (*Trigonella foenum-graecum* L.)

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Abstract

A field experiments were conducted in two successive rabi seasons, 2016-17 and 2017-18, at the Instructional Farm of Rajasthan College of Agriculture, Udaipur situated in the Sub Humid Southern Plain and Aravalli Hills of the state of Rajasthan, India to determine irrigation and weed management can improve fenugreek (*Trigonella foenum-graecum* L) growth performance and competitiveness with weeds, thus helping to achieve its yield potential. The experiment consisted of four irrigation levels (0.4, 0.6, 0.8 and 1.0 IW/CPE ratio) and four weed management treatments (Weedy check, PE application of pendimethalin + imazethapyr (RM) 0.75 kg ha^{-1} in conjugation with one hand weeding 40 DAS, imazethapyr 0.075 kg ha^{-1} 20 DAS followed by hand weeding 40 DAS and two hand weeding 20 and 40 DAS) thereby making sixteen treatment combinations. Amongst irrigation schedules irrigation at 0.8 IW/CPE ratio recorded significant improvement in various growth and yield parameters during both the years of study. PE application of pendimethalin + imazethapyr (RM) in conjugation with one hand weeding achieved the highest weed depression expressed in the lowest dry matter of broad-leaved, narrow-leaved and total weeds. Also, this treatment was the most superior treatment in increasing plant height and crop dry matter, primary branches plant^{-1}, crop growth rate, nodulation, pods plant^{-1}, seeds pod^{-1}, test weight, seed yield plant^{-1}, pod length and seed weight pod^{-1} of fenugreek.

Keywords: Fenugreek, Irrigation schedule, Weed management, IW/CPE ratio

Introduction

Historically, India has always been recognized as a land of spices. Rajasthan and Gujarat has been emerged as "seed spice bowl" and together contributes more than 80 per cent of total seed spices produced in the country. Fenugreek (*Trigonella foenum graecum* L.) is a leguminous seed spices in

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North-Western India as an important condiment crop during winter season. It is a multipurpose crop and has several medicinal uses. It's seeds substantially contain the steroid substances diosgenin which is used as a base material in the synthesis of sex hormones in oral contraceptive. India occupies prime position among the fenugreek growing countries of the world. In India it is mainly grown in Rajasthan, Madhya Pradesh, Gujarat, Haryana, Uttar Pradesh and Tamil Nadu. On national basis, during the year 2020-21, fenugreek occupied an area of 156156 ha with production and productivity of 241183 tonnes and 1544 kg ha^{-1}, respectively (Spice Board, 2022). Among the states in India, Rajasthan is the largest fenugreek producing state with contributes 45.30 per cent of total production and occupies an area of 90469 ha with the production of 109280 tonnes during *Rabi* 2020-21 (Spice Board, 2022). Water management has become the most indispensable factor for augmenting the crop productivity especially in legume crops because of their high susceptibility to both water stress and water logging at various growth stages. Irrigation should aim to restore soil water in the root zone to a level at which crop can fully meet its evaporation requirement. Different criteria were employed to supply water to the crop so that it does not experience the water stress at many stages of the crop growth and development. Recently irrigation is being scheduled on the basis of climatologically approach which is now considered as most scientific, since it integrate all weather parameters giving the natural weight age in a given climate plant continuum. In climatologically approach (IW/CPE), a known amount of irrigation water is applied when cumulative pan evaporation reaches at predetermine level. Weed is an important factor responsible for causing tremendous loss in fenugreek. Due to slow initial growth of fenugreek, it is more susceptible to weed problem hence simultaneous emergence and rapid growth of weed leads to severe weed crop competition for light, moisture, space and nutrients. In agriculture, weed causes more damage as compared to insect pest and diseases due to hidden losses caused by weed in crop production. If unchecked, it may reduce the seed yield to the tune of 14.2 to 69 % depending upon their density and duration of competition (Chovatia *et al.,* 2009). The presence of weeds is causing a shortage of the crop up to 40% (Soliman et al., 2015). The advantages of herbicide application are characterized by high efficiency in weed control, high selectivity and at the lowest cost, compared to other available weed control methods. Manual weeding is time consuming, back breaking and expensive, therefore; under such conditions use of herbicide remains the pertinent choice of farmers for controlling the weeds. Precise information on water and weed management in fenugreek is essential and inevitable. Hence, the study was carried out to evaluate effect of irrigation scheduling and weed management practices on growth and yield of fenugreek.

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Materials and Methods

The field experiment was conducted during *Rabi* season of 2016-17 and 2017-18 at Instructional Farm of Rajasthan College of Agriculture, Udaipur situated in the Sub Humid Southern Plain and Aravalli Hills of the state of Rajasthan. The soil of the experimental field of both the location was clay loam in texture having pH (8.1 and 8.0), electrical conductivity (0.89 and 0.84 dS/m), medium in organic carbon (0.76 and 0.68), medium in available nitrogen (400.50 and 372.80 kg ha^{-1}), medium in available P_2O_5 (24.80 and 20.70 kg ha^{-1}) and high in available K_2O (378.20 and 342.40 kg ha^{-1}) respectively during 2016-17 and 2017-18. The experiment was laid out in split plot design with four replications, keeping four levels of irrigation (0.4, 0.6, 0.8 and 1.0 IW/ CPE ratios) in main plot and four weed control treatments (Weedy check, pre emergence application of pendimethalin + imazethapyr (RM) 0.75 kg ha^{-1} in conjugation with one hand weeding 40 DAS, imazethapyr 0.075 kg ha^{-1} 20 DAS followed by hand weeding 40 DAS and two hand weeding 20 and 40 DAS) in sub plots. The fenugreek variety RMT - 305 was sown at 30 cm row to row spacing keeping seed rate of 25 kg per ha. Full dose of nitrogen and phosphorus was drilled manually through DAP and urea at the time of sowing. Cumulative pan evaporation was taken as the sum of the daily pan evaporation from USWB class-A. Irrigation water was measured by Parshall flume installed in the field channel. As per treatment, pre emergence herbicide pendimethalin + imazethapyr (Ready mix) @ 0.75 kg ha^{-1} was applied two DAS of crop while imazethapyr @ 0.075 kg ha^{-1} was applied 20 DAS. These herbicides were sprayed with knapsack sprayer fitted with flat fen nozzle using 500 litres of water per hectare after calibration. Hand weeding treatments comprised of hoeing and weeding operation 20 and 40 DAS performed with hand hoe.

Results and Discussion

Effect of irrigation levels

Significantly higher plant height at different growth stages was recorded with irrigation at 0.8 IW/CPE ratio over 0.4 and 0.6 IW/CPE ratio during both the years as well as in pooled analysis (Table 1). Further enhancement in levels of irrigation failed to significantly influenced plant height. The higher plant growth with 0.8 IW/CPE ratio might be attributed to maintenance of favourable and congenial moisture regime due to application of frequent irrigation which facilitated better water and

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nutrient absorption resulting in higher plant height. Significantly higher dry matter accumulation, CGR, RGR, number of nodules plant^{-1}, nodule dry weight was obtained with irrigation at 0.8 IW/CPE ratio which might be due to optimum availability of moisture at 0.8 IW/CPE ratio without any stress resulting in higher vegetative growth, more photosynthetic area and dry matter accumulation resulting in higher CGR and RGR. Significant enhancement in yield attributes *viz.,* pods plant^{-1}, seeds pod^{-1}, test weight, seed yield plant^{-1}, pod length and seed weight pod^{-1} were recorded under 0.8 IW/CPE ratio compared to 0.4 and 0.6 IW/CPE ratio. This proves that IW/CPE ratio of 0.8 maintained most optimum soil moisture for better growth parameters i.e., dry matter accumulation, plant height, branches plant^{-1}, crop growth rate, relative growth rate, nodules plant^{-1}; result in better yield attributes and yield performance of fenugreek crop during both the years of investigation and pooled basis. This significant enhancement in performance of yield attributes and yield components can be ascribed to greater availability of photosynthetes and its translocation towards the formation of reproductive organs that resulted not only in formation of significantly a greater number of pods plant^{-1} but it also significantly improved the pod and seed health (pod length, more seeds pod^{-1}, bold seed size and finally seed yield plant^{-1}). Significantly higher pooled values of seed yield (3244 kg ha^{-1}), haulm (6302 kg ha^{-1}), biological yield (9546 kg ha^{-1}) and harvest index (33.57 %) of fenugreek were obtained under 0.8 IW/CPE ratio.

Effect of irrigation and weed management practices on plant height and crop dry matter on pooled basis

Treatments	**Plant Height (cm)**				**Crop Dry matter (g plant^{-1})**			
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
Irrigation Management								
I_0 (0.4 IW/CPE)	10.0	32.7	40.3	42.1	0.57	4.45	15.15	18.60
I_1 (0.6 IW/CPE)	12.4	38.6	44.8	46.0	0.84	6.43	18.35	23.97
I_2 (0.8 IW/CPE)	15.1	45.3	54.1	55.3	0.92	8.11	20.75	30.88
I_3 (1.0 IW/CPE)	15.5	45.4	54.9	56.3	0.94	8.27	20.83	31.60

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SEm ±	0.2	0.3	0.5	0.5	0.01	0.08	0.15	0.26
CD (P= 0.05)	0.6	1.0	1.3	1.4	0.02	0.23	0.45	0.78
Weed Management								
W_0	11.0	34.9	42.0	42.7	0.64	4.19	14.30	19.29
W_1	14.7	43.6	52.2	54.2	0.92	8.20	21.32	29.49
W_2	12.8	40.3	48.1	49.6	0.80	6.71	18.56	27.13
W_3	14.5	43.2	51.8	53.3	0.91	8.16	20.90	29.14
SEm ±	0.1	0.2	0.2	0.4	0.01	0.06	0.16	0.18
CD (P= 0.05)	0.4	0.6	0.7	1.0	0.03	0.16	0.45	0.51

W_0 – Weedy check, W_1 – PE pendimethalin + imazethapyr (RM) *fb* one HW 40 DAS, W_2 – Imazethapyr + one HW 40 DAS, W_3 – Two HW 20 and 40 DAS

Effect of irrigation and weed management practices on growth attributes of fenugreek viz. CGR, Primary branches plant^{-1}, Number of nodules and their dry weight, Days to 50 % flowering and Days to maturity on pooled basis

Treatments	**Crop growth rate (g m^{-2} day^{-1})**		**Primary branches plant^{-1} at 75 DAS**	**Number of nodules plant^{-1}**		**Dry weights of nodules plant^{-1} (mg plant^{-1})**		**Days to 50 % flowering**	**Days to maturity**
	Between 30-60 DAS	**Between 60-90 DAS**		**40 DAS**	**60 DAS**	**40 DAS**	**60 DAS**		
Irrigation Management									
I_0 (0.4 IW/CPE)	4.31	11.89	4.88	12.31	21.60	27.33	51.05	53.7	117.7
I_1 (0.6 IW/CPE)	6.21	13.25	5.51	16.51	24.52	39.12	69.53	55.1	126.4
I_2 (0.8 IW/CPE)	7.99	14.04	6.29	19.74	26.05	45.03	81.41	61.1	131.0

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I_3 (1.0 IW/CPE)	8.14	13.95	6.43	20.15	26.70	46.29	82.29	61.3	132.3
SEm ±	0.08	0.13	0.07	0.20	0.26	0.57	0.45	0.5	0.8
CD (P= 0.05)	0.24	0.40	0.20	0.60	0.77	1.71	1.32	1.5	2.4
Weed Management									
W_0	3.94	11.23	4.55	11.78	19.49	25.24	57.20	62.3	123.8
W_1	8.08	14.59	6.44	20.01	27.91	46.02	75.63	55.6	129.5
W_2	6.57	13.16	5.78	16.48	23.15	39.54	70.32	58.4	126.6
W_3	8.05	14.15	6.35	20.44	28.33	46.98	81.13	55.0	127.5
SEm ±	0.07	0.19	0.04	0.18	0.16	0.35	0.44	0.4	0.7
CD (P= 0.05)	0.19	0.54	0.11	0.52	0.45	0.97	1.22	1.2	2.0

W_0 – Weedy check, W_1 – PE pendimethalin + imazethapyr (RM) *fb* one HW 40 DAS, W_2 – Imazethapyr + one HW 40 DAS, W_3 – Two HW 20 and 40 DAS

Effect of irrigation and weed management on yield attributes of fenugreek on pooled basis

Treatments	Pods plant^{-1}	Seeds pod^{-1}	Test weight (g)	Seed yield plant^{-1} (g)	Pod length (cm)	Seed weight pod^{-1} (g)
Irrigation Management						
I_0 (0.4 IW/CPE)	44.9	11.9	11.92	6.43	10.2	0.164
I_1 (0.6 IW/CPE)	51.7	13.2	14.51	9.95	10.9	0.220
I_2 (0.8 IW/CPE)	61.0	16.9	18.04	16.78	11.7	0.351
I_3 (1.0 IW/CPE)	61.8	17.2	18.28	17.23	11.8	0.354
SEm ±	0.6	0.2	0.10	0.16	0.1	0.004
CD (P= 0.05)	1.7	0.7	0.30	0.49	0.3	0.011

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Weed Management						
W_0	44.7	12.1	12.38	7.22	10.2	0.170
W_1	60.2	16.5	17.86	15.12	11.8	0.341
W_2	54.9	14.4	14.85	13.10	10.9	0.245
W_3	59.6	16.2	17.67	14.95	11.7	0.334
SEm ±	0.3	0.1	0.09	0.11	0.1	0.003
CD (P= 0.05)	0.7	0.4	0.26	0.30	0.2	0.008

W_0 – Weedy check, W_1 – PE pendimethalin + imazethapyr (RM) *fb* one HW 40 DAS, W_2 – Imazethapyr + one HW 40 DAS, W_3 – Two HW 20 and 40 DAS

Effect of irrigation and weed management on yield and economics of fenugreek on pooled basis

Treatments	Seed Yield (Kg ha^{-1})	Haulm Yield (Kg ha^{-1})	Biological Yield (Kg ha^{-1})	Harvest Index (%)	Net Return (Rs ha^{-1})	B/C Ratio
Irrigation Management						
I_0 (0.4 IW/CPE)	1571	4191	5762	26.83	27689	0.90
I_1 (0.6 IW/CPE)	2397	5511	7908	29.96	55099	1.72
I_2 (0.8 IW/CPE)	3244	6302	9546	33.57	80779	2.38
I_3 (1.0 IW/CPE)	3312	6427	9739	33.59	82168	2.35

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SEm ±	52	79	122	0.33	1719	0.06
CD (P= 0.05)	154	236	363	0.97	5108	0.17
Weed Management						
W_0	1642	4107	5750	28.23	31578	1.09
W_1	3142	6264	9406	32.74	78267	2.35
W_2	2648	5863	8511	30.33	61336	1.79
W_3	3092	6196	9288	32.66	74554	2.11
SEm ±	30	50	57	0.31	915	0.03
CD (P= 0.05)	84	139	161	0.86	2570	0.08

W_0 – Weedy check, W_1 – PE pendimethalin + imazethapyr (RM) *fb* one HW 40 DAS, W_2 – Imazethapyr + one HW 40 DAS, W_3 – Two HW 20 and 40 DAS

Application of irrigation at 0.8 IW/CPE ratio resulted in 94.18 and 34.81; 50.37 and 14.35; 65.67 and 20.71 per cent hike in pooled seed, haulm and biological yields, respectively over 0.4 and 0.6 IW/CPE ratio. No doubt, weed density and weed dry weight increased steadily with increasing in number of irrigation but at the same time seed yield was also increased. This might be due to fact that increased irrigation frequency, decreased the soil moisture stress which is turn resulted in higher leaf water potential, stomatal conductance and higher photosynthesis consequently increased dry matter production and ultimately higher seed yield. Data further striking that increase in seed, haulm and biological yield on increasing IW/CPE ratio from 0.6 to 0.8 was higher than the corresponding increase on raising IW/CPE ratio from 0.4 to 0.6 which reveals that IW/CPE ratios of 0.8 and 1.0 not only maintained sufficient soil moisture at critical stages of fenugreek crop but it met out the physiological, structural and metabolic requirements of fenugreek crop apart from meeting out the evapo-transpiration demand of crop. It also be due to increasing irrigation numbers might have caused faster growth of fenugreek plants and inhibited weed seed germination and the growth of early emerged weeds, which in turn, reduced the weed-crop competition resulting into higher seed yield.

Effect of weed management

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The major weed flora of the experimental field were *Chenopodium murale*, *Chenopodium album*, *Convolvulus arvensis*, *Melilotus indica*, *Cyperus rotundus*, *Cynodon dactylon* and *Phalaris minor* which were controlled by different weed management techniques. At each stage of observation pre emergence application of pendimethalin + imazethapyr (RM) followed by one hand weeding recorded significantly higher plant height, crop dry matter, CGR, branches plant^{-1}, nodules plant^{-1}, nodules dry weight plant^{-1}, however, its effect was statistically at par with two hand weeding. This might be due to severe competition by weeds for growth resources which made the crop plants inefficient to take up moisture and nutrients, consequently affected growth adversely. In general, the aforesaid improvements seems to be on account of direct impact of different weed management treatments through least crop-weed competition whereas, indirect effect might be least competition for plant growth inputs viz., light, space, water, nutrients etc. Similarly, under reduced density and dry matter of weeds, plants get sufficient space for optimum expansion of leaves and branches as early as possible. Under present investigation superiority of pre-emergence application of pendimethalin + imazethapyr (RM) along with one hand weeding could be ascribed due to their direct effect on reduced density and dry matter of weeds while indirect effect might be on account of improvement in nutrient uptake by crop compared to weedy check. Thus, congenial nutritional environment might have increased metabolic processes in plant resulting in greater plant height, thereby improving branches and ultimately resulting in higher dry matter accumulation plant^{-1}. Pre emergence application of pendimethalin + imazethapyr (RM) *fb* one hand weeding produced significantly higher pooled values of seed (3142 kg ha^{-1}), haulm (6264 kg ha^{-1}) and biological yield (9406 kg ha^{-1}), compared to rest of the weed management treatments except two hand weeding. Pre emergence application of pendimethalin + imazethapyr (RM) *fb* one hand weeding and two hand weeding resulted in 91.35 and 88.31; 52.52 and 50.86; 63.58 and 61.53 per cent hike in pooled seed, haulm and biological yield, respectively over weedy check . The significantly improvement in seed yield as a result of pre emergence application of pendimethalin + imazethapyr (RM) followed by one hand weeding and two hand weeding could be ascribed to the fact that yield of crop depends on several yield component which are interrelated. Under weedy situation, at early crop growth stage a greater part of resource present in soil and environment are depleted by weeds for their growth. The crop plants thus, faced stress which ultimately affected their growth, development and yield. Alike seed yield, haulm yield was also significantly increased under various treatment of weed management during the experiment over weedy check. Increase in haulm yield might be due the direct influence of various weed management

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treatments on the suppression of weeds. Thus, decrease crop weed competition resulted into increase plant height, crop dry matter accumulation, leaf area index, number of nodules plant^{-1} and branches plant^{-1}. Tiwari *et al.,* (2006), Chovatia *et al.*, (2007), Mehta *et al.*, (2010) also reported similar results in fenugreek.

Conclusion

It seems quite logical to conclude that higher production and net return from the fenugreek can be secured by scheduling irrigation at 0.8 IW/CPE ratio and efficient weed control can be achieved either by pre-emergence application of pendimethalin + imazethapyr (RM) along with one hand wedding 40 DAS under paucity of farm labourers or two hand weeding 20 and 40 DAS under availability of farm labourers.

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Millets with regard to food and nutritional security of India- A Review

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Abstract

Millets are traditional food for 59 crore people in Africa, Latin America and Asia. They are grown in 131 countries with an area of 71.2 m ha and production is around 86.3 m t. India produces 80% of Asia's millets and 20% of World millets. In 1965-70, millets contributed 20% of total food grain basketof India but now it comes down to 6%. Millets are considered as 'super food' because they provide not only major nutrients like protein, carbohydrates, fats etc. but also provide ample *amounts*of vitamins and minerals. It has also been reported that millet proteins are good sources of essential amino acids except lysine and threonine but are relatively high in methionine. Millets are also rich sources of minerals and dietary fibers when compared to rice or wheat and contains 9-14% protein and 70-80% carbohydrates. These are rich sources of phytochemicals and micronutrients. The quality of protein is mainly a function of its essential amino acids. Finger millet contains 44.7% essential amino acids of the total amino acids. Among the millets, pearl millet (Bajra) has the highest content of macronutrients and iron, zinc, Mg, P, folic acid and riboflavin. Finger millet records the highest amount of sulphur containing amino acids like methionine and cycteine besides containing the highest amount of Ca when compared to conventional cereals. In India, millets possess immense potential in our battles against climate change and poverty, and provide food, nutrition, fodder and livelihood security. The Government of India started the POSHAN Mission Abhiyanand laid emphasis on the nutritional significance of millets.

Key words: *Millets, super food, nutrition, livelihood security and poshan mission abhiyan*

Introduction

Millets are small grained cereals belonging to Gramineae family which include major millets like sorghum and pearl millet (which are tall growing and fairly drought tolerant) and minor millets with short slender culm and small grains possessing remarkable drought tolerance (ICRISAT and FAO, 1996).Small millets are a group of six crops comprising of finger millet, kodo millet, little millet, foxtail millet, barnyard millet and proso millet. They are considered as nutri- cereals and are source of food, feed and fodder (Sujata*et al.,* 2018).

(a) Genera and species: The term "millet' is often used loosely to refer to several types of small seeded annual grasses. Millets share a set of characteristics which make them unique amongst cereals. They belong to five genera, namely *Panicum, Setaria, Echinochola, Pennisetum, Paspalum,* and*Eleusine*. The genus *Pennisetum* includes about 140 species, some of which are domesticated and some grow in the wild. Most of the genera are widely distributed throughout the tropics and subtropics of the world (De Wet *et al*, 1984). Millets can be a valuable source of forage because of their rapid growth, high nutritive value and ability to survive stressful conditions such as drought.

(b) Important millet species:According to Hulse*et al.* (1980), the most important cultivated millet species are pearl millet (*Pennisetumtyphoides*), also known as bulrush millet; proso millet (*Panicummiliaceum*), also known as common millet; foxtail millet (*Setariaitalica*); Japanese barnyard millet (*Echinochloa* crus- gallivar or *E. colona*); finger millet (*Eleusinecoracana*), also known as birds foot millet or African millet and kodo millet (Paspalumscorbiculatum). Other millets include little millet (*Panicumsumatrense*), tef millet (*Eargrostistef*) and fonio millet *Digitariaexilis* and *D. iburua*) (Dogget, 1989).

(c) Millets grownin India

- The three major millet crops currently growing in India are jowar (sorghum), bajra (pearl millet) andragi (finger millet).
- Along with that, India grows a rich array of bio-genetically diverse and indigenous varieties of"small millets" like kodo, kutki, chenna and sanwa.
- Major producers include Rajasthan, Andhra Pradesh, Telangana, Karnataka, Tamil Nadu, Maharashtra,Gujarat and Haryana.

(d) History: The vernacular names of millets in India are given in Table 1. India is also the home for the species *Echinocholacolona* (Sawa) under barnyard millet. Many indigenous communities in Asia preferred millets as their grain crop for shifting cultivation. The long history of minor millet cultivation and their spread to different regions of the world, which are notable for extremely harsh farming conditions, had generated considerable genetic variability in these crops.Kodo millet is very hardy and possesses the highest drought resistance with potential to offer a good yield in a growing period between 80-135 days. Barnyard millet could be said to be the second hardiest millet with the ability to give a modest yield in 50-100 days. Finger millet is more widely grown in Africa and Asia,

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differentiated in to five races and shows wide variability in appearance, adaptability, maturityperiod, yield and quality. Foxtail millet may be ranked fourth in yielding ability. The yield potential of little and proso millets are relatively lower with proso millet being hardier.

Table 1. Vernacular name of different millets grown in different parts of India

English	Botanical	Alternate	Hindi	Kannada	Tamil	Telegu	Malayalam	Marath
Sorghum	*Sorghum bicolor*	Great Millet/ Milo/Chari	Jowar	Jola	Cholam	Jonnalu	Cholam	Jwari
Pearl millet	*Pennisetumglaucum*	Spiked Millet/ Bullrush	Bajra	Sajje	Kambu	Gantilu/Sazzalu	Kambu	Bajri
Finger millet	*Eleucinecoracana*	Rajika	Mandua/ Madua	Ragi	Kelvargu/ kezhvaragu	Ragulu	Muthari	Nachni
Barnyard Millet	*Echinocloafrumantacea*	Japanese Millet/Sawank	Jhangora/ Shama	Samai	Kuthiravaali	Odalu/Bonta/Chamula	-	Shamul
Foxtail Millet	*Setariaitalica*	Moha Millet/Italian Millet	Kangni	Navane/PriyanguThene	Tenai	Korra/Korralu	Thina	Rala
Kodo Millet	*Paspalum scrobiculatum*	Pakodi/Manakodra	Kodra	Harka	Varagu	Arikelu	Varagu	Harik

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Proso Millet	*Panicum miliaceum*	French Millet/Common Millet	Barri	Baragu	Panivaragu	Varigulu/ varigalu	Panivaragu	Vari
Little Millet	*Panicum miliare*	Goudli/Gondola	Kutki	same	Samai	Sama	Chama	Sava

(e) Importance in dietary need: Millets may have been consumed by humans for 7000 years and potentially had a pivotal role in rise of multi-crop agriculture and settled farming societies. Recently realizing the excellent nutritional composition of these grains, they are now called “nutricious grains” or “nutri cereals”.

Area, Distribution and Production

Millets are traditional food for 59 crore people in Asia and Africa. They are grown in 131 countries.

Table2. Millets area and production scenario over the globe during 2019

Regions	Area (m ha)	Production (m t)
Africa	48.9	42.3
America	5.3	19.3
Asia	16.2	21.5
Europe	0.8	2.0
Australia and New Zealand	0.6	1.2
India	13.8	17.3
World	71.8	86.3

- India produces >1.70 m t (80% of Asia’s & 20% of global production)
- Global average yield: 1229 kg/ha, India (1239 kg/ha)

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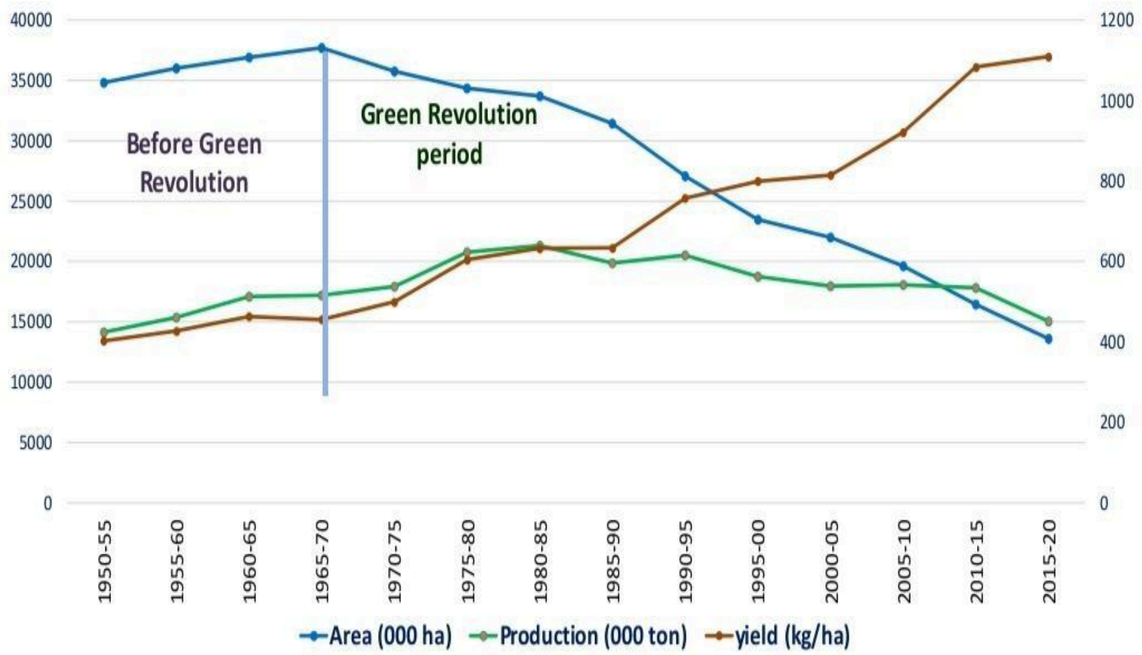

Figure 1. Quinquennial mean area, production and yield of millets in India

- Area decreased (56%), productivity has increased (228%) High adoption of high yielding varieties/ hybrids.
- Up to 1965-70: Millets- 20% of total food grain basket, now only 6% dominated by rice & wheat.

Agro-Climatic Requirement

Millets require warm temperatures for germination and development & are sensitive to frost. For these reasons, they are normally planted from mid-June to mid-July month. Optimum soil temperatures for seed germination are between 20°C and 30°C. Proso and foxtail millet are efficient users of water & grow well in areas of low moisture, partly because they are early and thereby avoid periods of drought. Millets are often grown as catch crops where other crops have failed due to

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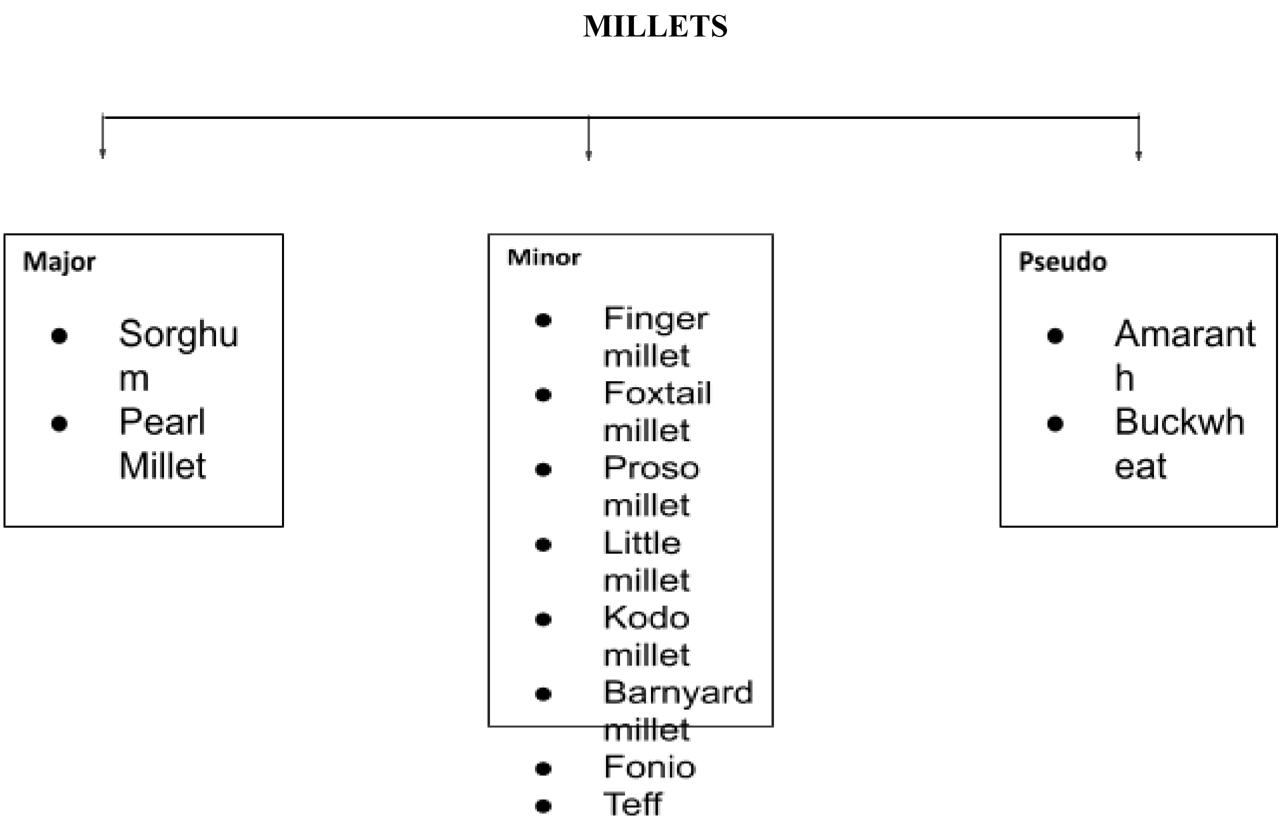
unfavorableweather. Millets produce well on well-drained loamy soils. They will not stand water-logged soils or extreme drought. Proso millet does not make good on coarse, sandysoils.

Classification



Super Food and Nutritional Significance

Millets are often referred to as Super food and its production can be seen as an approach for sustainable agriculture and a healthy world. Multidimensional benefits associated with millets can address the issues related to nutrition security, food systems security, and farmers' welfare. Further, many unique features linked with millets makes them a suitable crop which is resilient to India's varied agro-climatic conditions. Citing these factors, the year 2018 has already been declared as the National Year of Millets and India has called for declaring 2023 as the "International Year of Millets". However, in spite of acknowledging their significance as a superfood, general perception is that the millets are increasingly seen as "poor person's food". Therefore, it is necessary to re-brand coarse cereals/millets as nutri-cereals and promote their production and consumption.

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Quality food: Nutritional quality of food is a key element in maintaining overall human health. In addition to their cultivating advantages, millets are found to have high nutritive value comparable to that of major cereals such as wheat and rice.

It has also been reported that millet proteins are good sources of essential amino acids except lysine and threonine -but are relatively high in methionine. Millets are also rich sources of phytochemicals and micronutrients (Mal *et al*., 2010;Singh and Raghuvanshi, 2012). Millets are highly nutritious, non-glutinous and non-acid forming foods. Hence they are soothing and easy to digest. They are considered to be the least allergenic and most digestible grains available. Compared to rice (especially polished rice), millets release lesser percentage of glucose.

Finger millet is the richest in calcium, about 10 times that of rice or wheat. Considering the nutrient richness of these grains they are now considered as 'nutri-cereals' and not as 'coarse cereals'. Though millets are generally regarded as "coarse" grains, their potential for augmenting the grain supplies, as also to considerably bridge the protein gap is being increasingly realized. Millet, besides being a rich source of carbohydrates, is very easy to digest; it contains a high amount of lecithin and is excellent for strengthening the nervous system.

Millets are rich in B vitamins, especially niacin, pyridoxine and folic acid, as well as the minerals calcium, iron, potassium, magnesium and zinc. Finger millet carbohydrates comprise of free sugars (1-2%), starch (75-80%) and non-starchy polysaccharides consisting of cellulose and hemicellulose. It is a very good source of dietary fibre, micronutrients and polyphenols.

Among the millets, pearl millet (Bajra) has the highest content of macronutrients and iron, zinc, Mg, P, folic acid and riboflavin. It is significantly rich in resistant starch and soluble and insoluble dietary fibres . Finger millet seed coat is an edible material and contains good proportion of dietary fibre, minerals and phytochemicals. Finger and teff millet are good sources of dietary calcium and magnesium and iron content is significant.

Millets as probiotic and prebiotic: Probiotics are "living microorganisms" which when administered in adequate amounts confer a health benefit on the host . Fermented millet products act as a natural probiotic treatment for diarrhea in young children (Lei *et al*, 2006). In Africa, millet Koko is prepared in the form of fermented millet porridge and drink (Lei and Jacobsen M. 2004). Prebiotics are non digestible food ingredients that beneficially affect the host by selectively stimulating the growth and activity of one or a limited number of bacteria in the colon. Millets whole grain also shows prebiotic

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activity, which helps to increase the population of bacteria's that plays a key role to promote digestion. Malting reduces important beneficial biochemical changes in the millet grain.

Nutritional significance of millets: Nutritional composition of some of the major cereals including coarse cereals and millets (per 100g) is presented as below. Millets are nutritionally comparable or even superior to major cereals such as wheat and rice, owing to their higher levels of protein with more balanced amino acid profile (good source of methionine, cystine and lysine).

The neutraceutical importance of finger millet lies in its high content of calcium (344mg/100g), protein (6% to14%), dietary fiber (18 %), carbohydrates (65% to 75%), minerals (2.5% to 3.5%), phytates (0.48%), tannins (0.61%), phenolic compounds (0.3 to 3.00%) and trypsin inhibitory factors, and is recognized for its health beneficial effects, such as anti diabetic, anti- tumerogenic, anti-diarrheal, antiulcer, anti-inflammatory, anti-oxidant and anti-microbial properties (Devi *et al.,* 2014; Supriya*et al*., 1996;ChetanandMalleshi,2007). Finger millet is milled with the testa which is generally rich in dietary fiber and micronutrients to prepare flour and the whole meal is utilized in the preparation of traditional foods, such as roti (unleavened breads), ambali (thin porridge) and mudde (dumplings).

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Table 3: Nutrient composition of millets compared to wheat and rice (per 100g)

Food Grain	Protein (g)	Fat (g)	Crude Fibre (g)	Minerals		Sulfur Containing amino acids		Unsaturated Fatty Acids		
				Ca (mg)	Fe (mg)	Methionine (mg)	Cysteine (mg)	Oleic (mg)	Linoleic (mg)	Linolenic (mg)
Finger Millet	7.3	1.3	3.6	344	3.9	210	140	-	-	-
Kodo Millet	8.3	1.4	9.0	27	0.5	-	-	-	-	-
Proso Millet	12.6	1.1	2.2	14	0.8	160		53.80	34.90	
Foxtail Millet	12.3	4.3	8.0	31	2.8	180	100	-	-	-
Little Millet	7.7	4.7	7.6	17	9.3	180	90	-	-	-
Barnyard Millet	6.2	2.2	9.8	20	5.0	180	110	-	-	-
Sorghum	10.4	1.9	1.6	25	4.1	100	90	31.0	49.0	2.70
Bajra	11.6	5.0	1.2	42	8.0	150	110	25.40	46.0	4.10
Wheat(Whole)	11.8	1.5	1.2	41	5.3	90	140	11.50	56.30	3.70
Rice(rawmilled)	6.8	0.5	0.2	10	0.7	150	90	42.5	39.10	1.10

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Some Potential Health Benefits of Millets

a) **Millets for diabetes**: Lower incidences of diabetes have been reported in millet-consuming population. Millet phenolics inhibit like alpha – glucosidase, pancreatic amylase reduce postprandial hyper glycemia by partially inhibiting the enzymatic hydrolysis of complex carbohydrates.Inhibiters like aldose reductase prevents theaccumulation of sorbital and reduce the risk of diabetes induced cateract diseases. Finger millet feeding to the diabetic animals for four weeks, controlled the glucose level and improve the anti oxidant status, which hasten the dermal wound healing process .Dehulled and heat treated banyard millet has been reported beneficial for Type II diabetes in which low glycemic index for dehulled millet (50.0) and heat treated was recorded.

b) **Millets and aging**: The chemical reaction between amino group of proteins and the aldehyde group of reducing sugars, termed as non enzymatic glycosylation, is a major factor responsible for the complications of the diabetes and aging. Millets are rich in anti oxidants and phenolics like phytates, phenols and tannins which can contribute to the anti oxidant activity important in health, aging and metabolic syndrome (Hegde*et al.,* 2002).

c) **Millets against cancer and celiac disease**: Millets are known to be rich in phenolic acids, tannins and phytates that act as “anti nutrients”. However these anti nutrients reduce the risk of colon and breast cancer in animals. It is demonstrated that millet phenolics may be effective in the prevention of cancer initiation and progression in vitro The overall growing demand for novel, tasty and “healthy” foods together with the increasing number of people suffering from celiac disease has given birth to a new market consisting of cereal products made from grains other than wheat and rye. In this challenging market, oat, sorghum and millet have gained a special position. Celiac disease is an immune – mediated enteropathy triggered by the ingestion of gluten in genetically susceptible individuals. However, since millets are gluten free, they have considerable potential in foods and beverages that can be suitable for individuals suffering from celiac disease. Therefore millet grains and their functions have the potential to be useful in cancer prevention and for producing food products for celiac people.

d) **Millets for cardiovascular disease**: Obesity, smoking, unhealthy diet and physical inactivity increase the risk of heart attacks and strokes. Most of the world countries face high and

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increasing rates of cardiovascular disease. It has been demonstrated that rats fed with diet of native and treated starch from barnyard millet had the lowest blood glucose, serum cholesterol and triglycerides compared with rice and other minor millets. Finger millet and proso millet may prevent cardiovascular disease by reducing plasma triglycerides in hyper lipidemic rats (Lee *et al*., 2010). Diversification of food production must be encouraged both at national and household levels in tandem with increasing yields. Providing more healthful and traditional whole-grain and multigrain substitutes for refined carbohydrates can be one important aspect of therapeutic dietary modification and promoting utilization of minor-grain foods (Singh and Raghuvanshi 2012)

Need For Promotion of Millets

a) **Climate resilient crop**: As millets are resistant to climatic stress, pests and diseases, this makes them a sustainable food source for combating hunger in changing world climate. Further, millets are not water or input-intensive, making them a sustainable strategy for addressing climate change and building resilient agri-food systems.

b) **Nutritional security**: Millets are high in dietary fibre,nutri-cereals are a powerhouse of nutrients including iron, folate, calcium, zinc, magnesium, phosphorus, copper, vitamins and antioxidants. They are not only important for the healthy growth and development of children but have also been shown to reduce the risk of heart disease and diabetes in adults. Millets, being gluten free and low glycemic index food are good for diabetic persons and can help to combat cardiovascular diseases and nutritional deficiency.

c) **Economic security**: Millets can be grown on dry, low-fertile, mountainous, tribal and rain-fed areas. Moreover, millets are good for the soil, have shorter cultivation cycles and require less costintensive cultivation. Given these features, low investment will be needed for production of millets and thus can prove to be a sustainable income source for farmers.

Subdued Use of Millets

- **Green Revolution**: With the Green Revolution, the focus was on food security and high-yielding varieties of wheat and rice. An unintended consequence of this policy was the

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gradual decline in the production of millets. Further, the cost incentives provided via MSPs to wheat and rice, discouraged production of millets.

- **Increased demand for processed food**: In parallel, India saw a jump in consumer demand for ultraprocessed and ready-to-eat products, which are high in sodium, sugar, trans-fats and even some carcinogens. With the intense marketing of processed foods, even the rural population started perceiving mill-processed rice and wheat as more aspirational.
- **Double burden:** This has led us to the double burden of mothers and children suffering from micronutrient deficiencies and the astounding prevalence of diabetes and obesity.

Steps Taken by the Government

- **Increase in MSP:** The government has hiked the MSP of Millets, which came as a big price incentive for farmers. Further, to provide a steady market for the produce, the government has included millets in the public distribution system.
- **Input support:** The government has introduced provision of seed kits and inputs to farmers, building value chains through Farmer Producer Organisations and supporting the marketability of millets.
- **Integration approach:** The Ministry of Women and Child Development has been working at the intersection of agriculture and nutrition by setting up nutri-gardens, promoting research on the interlinkages between crop diversity and dietary diversity and running a behaviour change campaign to generate consumer demand for nutri-cereals.

Way Forward

- **Way forward changing the narrative**: There is a need to change the general perception around consumption and trade point of view associated with millets and to re-brand coarse cereals/millets as nutri-cereals. Further, civil society can begin the mass involvement by taking small steps towards choosing healthier foods, which are good for the environment and bring economic prosperity to our farmers.
- **MSP on lines of wheat and rice:** Government can try on a pilot basis for providing MSP to millets on the lines of wheat and rice (state guarantee of procurement at MSP.).

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- **Mission mode initiative**: The government can encourage farmers to align their local cropping patterns to India's diverse 127 agro-climatic zones and promote cultivation of millets with local topography and natural resources. Inter-Ministerial Approach: There is a requirement of a multi-ministerial policy framework that is aimed towards building anself sufficient India and resonates with the global call for self-sufficiency and sustainable development.

Conclusion

Millets are easily available and cheap. Millets contain many major and minor nutrients like carbohydrates, protein, fat, dietary fibre, vitamins and minerals as well as antioxidants and phytochemical.This year, the United Nations General Assembly adopted a resolution declaring 2023 the International Year of Millets, as proposed by India to the Food and Agriculture Organization (FAO). Millets possess immense potential in our battles against climate change and poverty, and provide food, nutrition, fodder and livelihood security. Being hardy crops, they can withstand extreme temperatures, floods and droughts**.**

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Research Article

Protein analysis for study of spot blotch disease in wheat

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Abstract

Spot blotch disease of wheat is now considered as one of the major constraints in wheat growing regions specially in South East Asia, Australia and Latin American countries where warm humid conditions persist during wheat crop season. Due to the tremendous breeding efforts, new partially resistant lines have recently been released. However, the lack of complete resistant genotypes and insufficiency of knowledge about the resistance mechanism still hamper sustained breeding efforts.Comparative investigationof the interaction of *Bipolarissorokiniana* with moderate resistant genotype Chirya 3 and susceptible genotype DDK 1025 will help in understanding the genes involved in pathogen resistance. Hence, Plant pathogen system under greenhouse conditions was established and tissue was collected after 24 hr. of inoculation. Protein was extracted from collected tissue and used for protein extraction method optimization for quantitative expression analysis using 2-D gel electrophoresis. Protein extraction protocol optimized using TCA-acetone extraction protocol was found to be best suitable for plant pathogen interaction analysis. The study of *B. sorokiniana* and wheat interaction at protein level will give overview of resistance mechanism.

Key words: *Bipolaris sorokiniana, Protein, SDS-PAGE, IEF*

Introduction

Wheat is considered as the most widely grown and consumed food crop of the world and is the staple food of around 35% of the world's population. The present (2023) wheat production is about 787 million tons(http://faostat.fao.org/) and to feed the world's ever-growing population in 2050, there will be a requirementto produceabout 1040 million tons of wheat (Pingali et. al., 1999). To reach this target, it is crucial to keep the crop free from various abiotic as well as biotic stresses.In recent years, spot blotch, caused by *Bipolarissorokiniana*, has emerged as a serious concern for cultivation of wheat in warmer and humid regions of the world. Extensive economic loss in wheat production has occurred due to the severity of spot blotch in the last 20 years (Sharma and Duveiller, 2006).Spot blotch is a major biotic constraint for wheat in the Gangetic plains and is the main restraining factor forwheat production in South-East Asia (Chowdhury, et. al., 2013). Nearly 12 million hectares of land under

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cultivation are affected in South East Asia and Latin American countries(Nagarajan and Kumar 1998). The pathogen affects almost all the crops belonging to *Graminacae* family (Pandey et al., 2005).

Exact yield losses due to this fungal pathogen have been reported to be difficult, due to co-infecting pathogens in the field (Mattias, 2008).However, reports show the estimated yield losses up to 15.5 to 19.6% (Dubin and Van Ginkel 1991), 20 to 80% (Duveiller and Gilchrist 1994), which may reach upto 100% under severe infection conditions (Mehta, 1998). Currently, *B. sorokiniana* is a pathogen of major concern at national level in India and its frequency is highest in north-eastern plains zone amongst the six agro climatic zones due to the prevalence of hot and humid weather conditions (Sjöberg, 2005).

Bipolarissorokiniana is a hemibiotrophic fungus having both biotrophic and necrotrophic phases. The biotrophic growth phase is limited to a single epidermal host cell, while invasion of the mesophyll tissue and host cell death is the characteristic of thenecrotrophicgrowth phase. *B. sorokiniana* causes foliar spot blotch, root rot, black point on grains, head blight and seedling blight of wheat and barley (Kumar et. al., 2002).

Barley and wheat are the most economically important plantsthat are infected by this fungus. The infection usually starts from seeds, infected soils or from host debristhat transmits conidia via physical contact or rain splashes. Foliar spot blotch leads to decrease the photosynthetic capacity of theleaf, resulting in early senescence. Common root rot decreases the water andnutrition uptake efficiency, causing weak seedlings which subsequently wither and die. In avirulent *B. sorokiniana*strain, about 90% of the conidia starts togrow, forming germ tubes and germlings or hyphae after 3h only. The germ tubes and hyphae of *B. sorokiniana*are surrounded by extra cellular matrix (ECM) that provides a beneficial environment for the fungus (Åkesson et. al., 1995; Apoga and Jansson, 2000).

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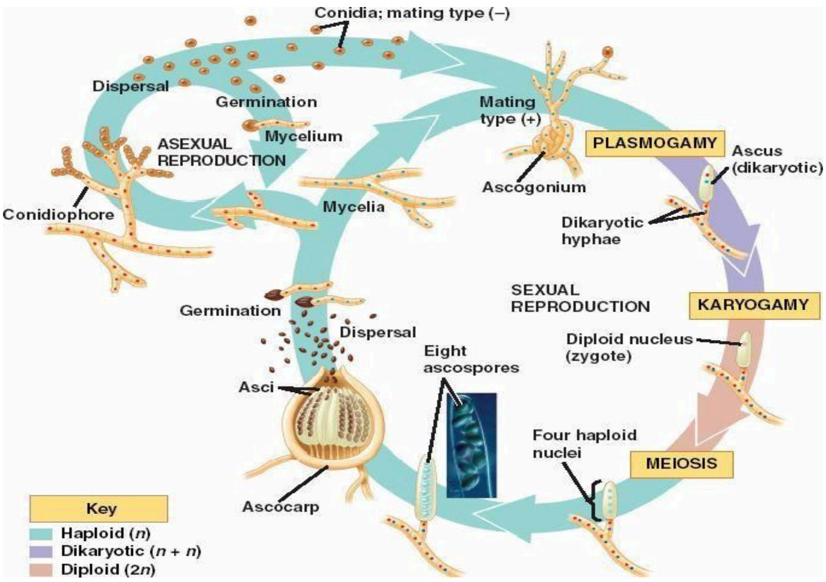

Figure1: Life cycle of Ascomycetes (*B. sorokiniana*)

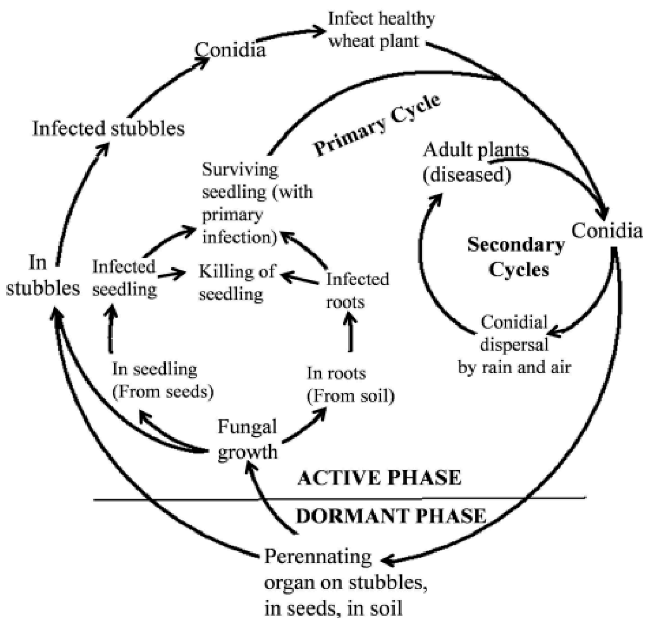

Figure2: Disease cycle of *Bipolaris sorokiniana*

At the initial stage of infection there is no sign of chlorotic margin. In case of a susceptible genotype the small lesions extend very rapidly and ultimately reach into several centimeters in the later stage (Jones and Clifford 1983; Mathre, 1987). Often yellowingextending from the lesion is observed

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due to toxin production. Later such spots coalesce each other thus result blight on large leaf portion.Disease incidents of wheat caused by *B. sorokiniana*can be controlled in a number of ways. Integrated pest management is by far the best method of controlling the pathogen (Mehta, 1993; Dubin and Duveiller 2000). Such program integrates the use of: (i) cultural practice, (ii) crop rotation, (iii) seed treatment, (iv) biological control, (v) foliar fungicide and (vi) disease resistant varieties (Acharya et. al., 2011, Kumar et. al., 2020).

Despite several studies, no effective controlling measure has been devised yet.In order to achieve any ideal controlling measure for plant disease, it is very important to understand the mechanism involved in defense response during plant-pathogen interaction.This research has focused on the details of the interaction using protein analysis approach for identification of novel resistant proteins.

Material and Methods

Samples required for Spot blotch system in green house

- DDK 1025 seeds:*Triticumdicoccum*, susceptible to spot blotch
- Chirya 3 seeds: *Triticumaestivum*, moderate resistant to spot blotch
- *Bipolarissorokiniana* isolate

a. Plant pathogen system setup

Seeds of DDK 1025 and Chirya 3 were sterilized by giving 1% NaOCl treatment for 5 minutes followed by 3 washes of sterile distilled water, 5 minutes each.Sterilized seeds were imbibed in sterile water for 6 hrs followed by *in vitro* germination under aseptic conditions and then transferred to after germination. Germinated seeds were sown in autoclaved soil rite and allowed to grow in greenhouse.At two leaf stage, half of the plants were inoculated with spore suspension ($2x10^3$/ml) of *B. sorokiniana*while rests were mock inoculated with water having 0.1% tween-20 for control.Plants were regularly monitored for growth.

b. Tissue collection

Leaf tissue was collected from the above experiment for protein analysis. Tissue was collected at 24 hr. post inoculation in 3 biological replicates. Collected leaf tissue was immediately frozen in liquid Nitrogen and was stored at -80ºC. The four different samples were collected and labelled as follow

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1. SI: Susceptible Inoculated plant (DDK 1025 inoculated)

2. SC: Susceptible Control plant (DDK 1025 control)

3. RI: Moderate resistant inoculated plant (Chirya 3 inoculated)

4. RC: Moderate resistant control plant (Chirya 3 control)

c. Protein extraction

Protein extraction was performed using the TCA- acetone precipitation method. For this purpose, 500 mg of leaf tissue was finely grind in liquid nitrogen and 1 ml of 10% TCA in acetone containing 2 % β-ME was added to each tube. Tube was kept at -20˚C for 1 hr. and spinned it at 16,000 rpm for 1 hr. and then supernatant was removed. Pellet was washed 3 times with ice cold 100% Acetone by 30 min spin at 12000 rpm at 4˚C. Supernatant was removed and the pellet was retained. Pellet was driedby evaporating the acetone. 1 ml of IEF buffer (CHAPS 4%, Thio-Urea 2 M, Urea 8 M, DTT 18 mM)was added to it and spinned it at 16,000 rpm for 30 min. The supernatant was taken gently into another tube and stored at -80˚C.

d. Protein Quantification

Protein extracted using TCA-acetone precipitation method was quantified using Bradford protein. A series of Bovine Serum Albumin (BSA) standard solutions of known concentrations were prepared by diluting a 2 mg/ml stock solution of BSA in distilled water. Standards were prepared as shown in Table 1. For quantification, 50 µl of the protein from tissue samples were dilutedto make equal volume (500 µl) using distilled water. The concentration of the protein sample should be within the linear range of the standard curve. Then, add 500 µl volume of Bradford reagent to each tube and mix well by inverting the cuvette several times. The cuvettes were incubated at room temperature for 5 minutes. During this time, the Bradford reagent binds to the protein, resulting in a shift in the dye's absorption spectrum and a change in color from brown to blue.Absorbance was measured at 595 nm in Dual beam Spectrophotometer (Lab-India, India).

Table 1: Preparation of standards of BSA for Protein estimation

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Tube no.	*BSA Standard (2mg/ml) Volume (µL)*	*Milli Q water (µl)*	*Final BSA concentration*
1	500	0	2
2	375	125	1.5
3	250	250	1.0
4	187.5	312.5	0.75
5	125	375	0.50
6	62.5	437.5	0.25
7	31.25	468.75	0.125

e. SDS-PAGE: SDS- PAGE was performed for extracted proteins. 10 µg of protein was loaded onto 5% stacking gel on the top of 10% resolving gel using a Bio-Rad Page system and allowed to run under applied constant voltage (80 V). Gels were prepared using the components as mentioned in the Table 2.

Table 2: Components of SDS-PAGE gels

Component	**5% Stacking Gel**	**10% Resolving Gel**
40% Acrylamide	0.5 ml	5.0 ml
1.5 M Tris (pH 6.8)	1.25 ml	5 ml
SDS	100 µl	2.5 ml
2% bis-Acrylamide	0.1 ml	2.6 ml
Milli Q Water	3 ml	4.8 ml
APS	25 µl	100 µl
TEMED	5 µl	10 µl
Final Volume	5 ml	20 ml

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f. 2-D Polyacrylamide Gel Electrophoresis

Two-dimensional gel electrophoresis (2-D electrophoresis) was performed for leaf tissue proteins extracted using TCA-Acetone extraction protocol. Proteins from each sample were loaded onto 7 cm gel strip having pH range 3-10 for one dimensional electrophoresis. Buffer containing 0.5% carrier ampholyte containing 100 µg of protein from each tissue sample was incubated in strips for 16 h for rehydration. The rehydrated strips were focused on Isolelectric focusing unit (Bio-Rad, India) at 50-250 V for 30 min. and 250-4000 V for 2 h, followed by 4000-10000 Vhr for a period of 2 h. Focused strips were washed with equilibration buffer I (20% Glycerol, 1.5 M Tris pH 8.8, 6 M Urea, 2% SDS, Dithiotritol 2%) for 15 min. Strips were then transferred to equilibration buffer II (20% Glycerol, 1.5 M Tris pH 8.8, 6 M Urea, 2%SDS, Iodoacetamide 2.5%) for 15 min. These equilibrated strips were then placed on 10% resolving gel and were sealed using 0.5% agarose containing Bromophenol Blue tracking dye. After isoelectric focusing, these strips were further subjected to PAGE for second dimensional electrophoresis as per the details of the gels prepared as mentioned in Table 2.

After completion, the gel was removed and stained using silver staining protocol.Fix the proteins using fixative (40 % methanol, 10 % acetic acid, 50 % water) for overnight. Wash the gel with 30 % ethanol (wash solution) three times for 20 min each. Reduce the proteins by adding reducing solution (0.02% solution of sodium thiosulphate) and incubate for 1 min. Wash the gel with water three times for 30 sec. Add 50 ml of Silver stain (2 gm silver nitrate, 200 µl formaldehyde in 1 liter water) to the gel for 20 min (use chilled solution). Wash the gel with water three times for 30 sec. Add the Developer solution (30 gm sodium carbonate, 5 mg sodium thiosulphate, 500 µl formaldehyde in 1 liter water) until the protein bands are visible. Add the Stop solution and leave the gel in this solution.

Result

Protein Quantification and SDS-PAGE

Extracted proteins were stored in -80ºC. The protein yield using Bradford method was found to bein the range of 25-27µg/gm of leaf tissue as shown by absorbance in Table 3.

Table 3: Absorbance of protein samples observed at 595 nm

S. No.	BSA conc.	1stSet	2ndSet	Average
1	0.125	0.172	0.174	0.173

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2	0.250	0.244	0.242	0.243
3	0.50	0.417	0.375	0.396
4	0.75	0.565	0.545	0.555
5	1.0	0.880	0.878	0.879
6	1.5	0.925	0.934	0.932
7	2	0.971	0.971	0.931
8	SC	0.523	0.527	0.525
9	SI	0.546	0.534	0.540
10	RC	0.523	0.529	0.526
11	RI	0.516	0.520	0.518

Extracted protein was analysed for quality assessment before 2D-PAGE using SDS-PAGE run as shown in Figure 3.

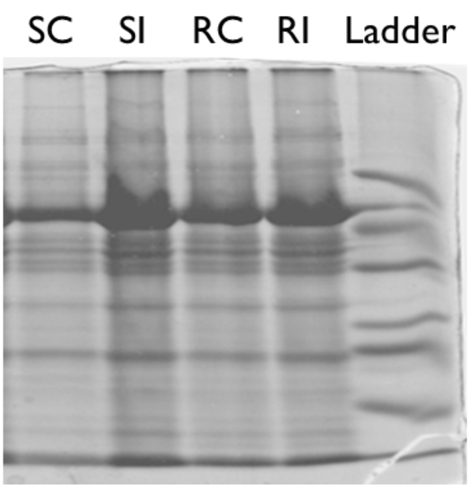

Figure 3: Four samples analysed for protein quality on SDS-PAGE

2-Dimensional PAGE Analysis:

After 2-DPolyacrylamide Gel electrophoresis,the gels were observed for differential protein expression. The gels showed difference in their band pattern for several proteins (Figure 4).

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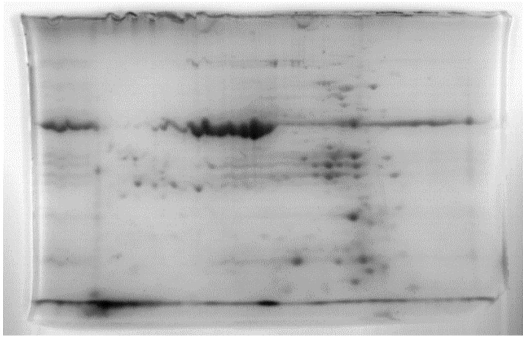
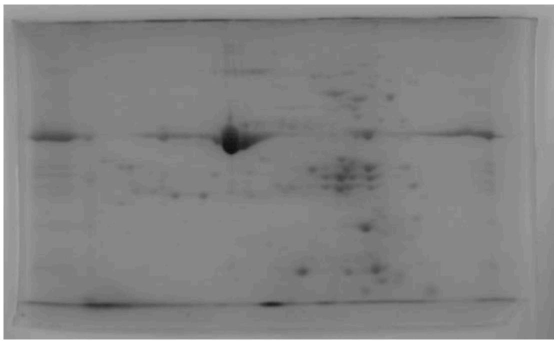
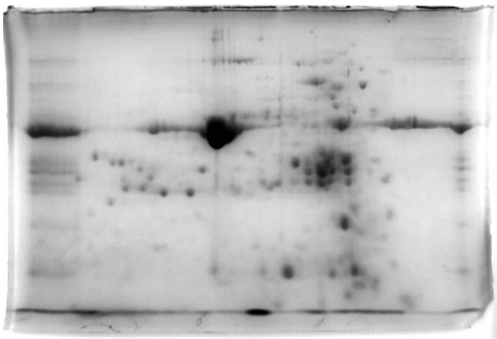
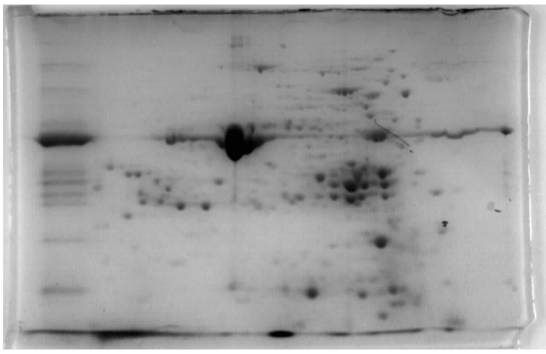




(A) (B)





(C) (D)

Figure 4: 2D-PAGE gel images of protein extracted from spot blotch leaf samples (A) SI (B) SC (C) RI (D) RC

Discussion

In wheat, little is known aboutthe physiological and molecular events regulating geneexpression under spot blotch conditions. It is important toanalyze pathogen-responsive gene expression in resistantand susceptible wheat lines, as it may increase ourunderstanding of the molecular mechanism of *Bipolaris*infection and the role of gene expression in spotblotch resistance.Interaction study experiment can help us to understand the plant response against fungal pathogen. With this intension, susceptible (DDK 1025) and moderate resistant (Chirya 3) plants were grown under spot blotch specific conditions in green house. Protein extraction method was optimized to get the good protein yield from perm gram of collected tissue sample and isoelectric focusing method conditions were also optimized. TCA-acetone extraction method was reported as best method for protein extraction from

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Spot blotch samples. The differentially expressed protein spots from the 2D –PAGE can be subjected to mass spectrometry analyses and candidate resistance genes can be identified for their role in interaction and/or resistance mechanism. Thefunctional genomic approach including transcriptomics and RT-PCR need to be explored andemployed on larger scale to mitigate the problems ofspot blotch disease in wheat. Integrating conventionalbreeding, molecular approach, need based applicationof fungicides and cultural options will offer eco-friendlyand cost effective control of this disease in different partsof the world.

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Effect of fertilizer Application on Crop Growth, Yield And Water Use Efficiency of *Utera* Crops in the Lowland Rainfed Rice Ecosystem

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Abstract

A field experiment was undertaken at Instructional Farm, Jaguli of Bidhan Chandra Krishi Viswavidyalaya, West Bengal to study the performances of *utera* crops as influenced by fertilizer management in rainfed rice ecosystem during *rabi* season of 2018-19 and 2019-20. The experiment was conducted with 3-main plot treatments consisting 3 *utera* crops viz. linseed, lentil and lathyrus; and 3 sub-plot treatments of fertilizer management viz. Suphala (NPK 15:15:15) @ 150 kg ha^{-1} (22.5 kg N), DAP (NP18:46) @ 125kgha^{-1} (22.5kgN) and DAP spraying at 20, 40 & 60 days after sowing @ 2g/lit of water respectively in Split-Plot design with 3 replications. The results of experiment in the lowland rainfed rice ecosystem revealed that lathyrus crop recorded the maximum yield of 725 kg ha^{-1} followed by lentil (721) and linseed (404) *utera* crops. In the experiment, soil application of Suphala (15:15:15) @ 150 kg ha^{-1} gave the highest grain yield (650 kg ha^{-1}) followed by DAP soil application (634) and DAP foliar spray(566).The variation in crop growth and yield attributes of *utera* crops were also similar in trend as noted crop yields. The variation in actual ET of utera crops was noted. Lathyrus crop has the lowest ETa (133.3 mm), whereas, linseed had maximum ETa value of 182.0 mm. Crop water use efficiency value was more in lathyrus (5.42kg/ha-mm) with suphala but least value was noted in linseed (2.42 kg/ha mm) with DAP foliar spray. The maximum benefit cost ratio (3.03) was obtained in lentil with DAP soil application. Considering the results of the experiment, linseed and lathyrus may be grown as utera crop with the fertilizer Suphala (15:15:15) @ 150 kg ha^{-1} but lentil crop may be with Diammonium Phosphate (18:46) @ 125 kg ha^{-1} in low land rice ecosystem of lower Indo-Gangetic Plains.

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Key words: Fertilizer management, Rainfed rice ecosystem, *Utera* crops, Yield, Water use efficiency.

Introduction

The rainfed lowland rice ecosystem in the Lower Gangetic Plains of eastern India is characterized by high rainfall, fine-textured soils, bowl shaped topography, stagnation of rain water and chances of flash flood in the rainy season (Sarkar *etal*., 2007). Earlier, the area is mostly covered by long duration (140-155 days) transplanted rice during rainy seasons and there after lands remain mostly fallow. The moisture status of *aman* rice leaves has a great scope for growing a second crop in *rabi* in lowland situation. Sometimes, the farmers of the areas grow *utera* crops in post rainy season utilizing the in-situ soil moisture. In rainfed agriculture, water availability is the primary factor controlling crop productivity. Hence, there is a good scope of growing wheat, lentil, grass pea, oat, linseed, gram, mustard etc. *aspaira* crops after transplanted rice. Intensification of existing agricultural systems is the need of the hour to take care of the rising demand of food grain production in the country (Kumar *et al*., 2016). To grow lentil as relay crop with rice in rice-fallow during post-rainy season through utilizing the carry-over soil water and residual soil fertility (Bandyo padhyay *et al*. 2016). Timing of tillage operation is the main difficulty due to muddy condition or water stagnation in the fields at the time of rice harvest which results in delayed sowing. These problems could successfully be overcome by growing of *rabi* crops under no- tillage condition as *paira* crops by sowing seeds of different winter crops before the harvest of transplanted *kharif* rice in moist land. The land preparation of the winter crops is often difficult due to aberrant onset and withdrawal of monsoons (Parya *etal*.,2010).Under this situation, relaycroppingmay be helpful for getting proper time of sowing for succeeding crop after *kharif* rice (Sharma *et al*., 2014). In West Bengal, it is a general practice of the farmers to sow various winter crops like lentil, lathyrus, chickpea field pea and linseed in the standing rice crop field, just before the harvest to ensure germination using the residual moisture and to avoid tillage operations (Duary *etal*., 2013). Growing of *paira* crops makes the avenue of including more crops in sequences by omitting the time lag between two successive crops as well as reduces the total cost of cultivation. Thus, crops having low water requirement, should be fitted suitably in such situations. The nutritional management for maximizing yield in pulses and oilseeds is

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the need of the day to overcome the malnutrition of the people in the developing countries. Since *paira* crops in relay cropping with rice suffers from nutrientional stresses during the reproductive phase, late application of N is effective in reducing flower and pod drop in legume and in increasing seed yield. It is also known that active nodulation of pulse crop stops after 45 to 50 DAS and at that time, the positive effect of supplying legume plants with supplementary nitrogen was found to have beneficial effects on enhancing growth and increasing seed yield by quick supply of nitrogen. Legumes generally require higher amount of phosphorus as the process of symbiotic nitrogen fixation consumes a lot of energy. Therefore,the scope of fertilization becomes confined to foliar spray or top dressing (Gupta and Bhowmick, 2005). Foliar application of Di-ammonium phosphate (DAP) at such stages which is superior to basal nitrogen and phosphorus fertilization as the former provides a continuous supply of nutrients for a longer crop growing period, and thus possibly facilitates a steady translocation of the photosynthates resulting in an increase in crop yields (Sarkar *etal.,*2018). So, the present experiment was carried out to study the performances of *utera* crops to nutrient management in lowland rice ecosystem in Lower Indo- Gangetic Plains of West Bengal.

Materials and methods

Field experiment was conducted at the Agricultural Instructional Farm, Jaguli, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal (22°87'N latitude, 88°32' E longitude, 9.75m above mean sea level)to study the performance of *utera* (no-till) crops as influenced by nutrient management in rice ecosystem during *rabi* (winter) season of 2019-20 and 2020-21. The experimental site falls under sub- tropical sub-humid climate.

Table 1. Meteorologicaldata duringthe experimentalperiodduring2018-19and2019-20(mean)

Month	Temperature (°c)		Relative humidity (%)		Total rainfall (mm)	Pan evaporation (mm day^{-1})	BSS (hr)
	Max.	Min.	Max.	Min.			
November	29.48	14.76	96.96	59.56	44.3	2.03	7.77
December	32.48	10.41	96.61	57.06	26.8	1.40	5.78
January	23.34	9.97	97.19	51.80	0.0	1.55	8.85
February	29.45	12.99	97.21	46.10	0.0	2.22	12.05

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March	33.99	18.04	94.06	44.93	0.0	3.93	6.59

Source: Department of Agricultural meteorology and Physics, B.C.K.V, Mohanpur Nadia

The average rainfall is 1450 mm, 75% of which is received during June to September. During the crop growth period maximum temperature ranged between 23.34° to 33.99°C and minimum temperature varied between 9.97 to 18.04 ° C (Table1). The maximum relative humidity varied from 94.06 to 97.21% and minimum relative humidity varied from 44.93 to 59.56%. The total rainfall was distributed throughout the experimental period but the highest rainfall received in the month of November (44.3 mm) followed by December (26.8 mm).

Table 2. Soil texture, bulk density and saturated hydraulic conductivity in the soil profile of lowland rice ecosystem

Soil layers (mm)	Textural group(percent)			B.D (Mg m^{-3})	Saturated hydraulic conductivity(mmh^{-1})
	Sand	Silt	Clay		
0-150	46.14	24.25	29.61	1.41	4.6
151-300	38.23	26.32	35.54	1.46	1.8
301-450	32.13	29.19	38.68	1.51	1.5
451-600	45.32	23.42	31.26	1.48	2.8
601-1200	56.12	16.23	27.65	1.46	7.2

The texture of the experimental soil was sandy clay loam and belongs to the order in ceptisol with medium fertility and almost neutral in soil reaction (Table2). The experiment was conducted on a medium land, well-drained Gangetic alluvial soil. The experiment was laid down in split-plot design with three replications comprising of different *utera* crops in mainplots (C_1-LinseedcvNeela,C_2-Lentil cvMaitri, C_3- Lathyrus cv Ratan) while different nutrient management in sub plot i.e. (N_1- Suphala (NPK15:15:15) @ 150kgha^{-1},N_2-DAP (NP18:46) @ 125kgha^{-1}, N_3-DAP spray 3 times (at 20,40,60DAS).

Each plot had an area of 4.0 m × 3.0 m. The seeds of lentil, lathyrus and linseed were broadcast before the rice harvesting. Necessary field operations like weeding and control of diseases-pests were done as and when required by the crop. However, fertilizer application was provided according to the treatment details.

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The crop was harvested when the plant become yellowish to brown and had around optimum moisture in the grain. Harvested crops were kept in the field for2-3daysforsun-drying. Thereafter, the bundle of the harvested crop of each plot was taken to a clean threshing floor and threshing was done plot-wise separately. Growth parameters *viz.* plant height, dry matter accumulation(DMA),crop growth rate (CGR), primary and secondary branch per plant at flowering stage, nodule per plant were recorded periodically at 30,45, 60DAS and at harvest. Yield components namely plant population at the time of harvest, number of pods plant^{-1}, number of seeds pod^{-1}, 10-pod weight, test weight (1000-seed weight) were recorded at harvest. After threshing the grains were properly sun-dried, cleaned, weighed and finally converted into kg ha^{-1}. Strover yield was also estimated as kg ha^{-1}.Estimation of available nutrient status of soil after harvesting of crop following standard methods. To study the water expenditure in terms of ET_a and water use efficiency (WUE). The data collected on growth parameters, yield components and yields were analyzed following the method of analysis for split-plot design as described by Gomez and Gomez (1984). The significance of different sources of variation was tested at probability level of 0.05. The standard error of mean (S.Em) and the value of CD were indicated in the tables to compare the difference between the mean values.

Results and Discussion

Effect on crop growth

The plant growth in terms of plant height of *utera* crops was significantly influenced by the nutritional management practices. Among the *utera* crops linseed, lentil and lathyrus, plant height increased progressively with the advancement of crop growth.Variations due to crop nutrition's were much noted at harvest (Table 3). At harvest plant height of linseed, lentil and lathyrus varied from 45.0 to 61.9 cm and the linseed crop recorded tallest plant height of 61.9 cm. In the experiment *utera* crops fertilized with Suphala (NPK 15:15:15) recorded the tallest plant height 67.6 cm followed by 56.4 cm and the shortest plant height 49.5 cm was recorded under DAP spray treatment. Higher plant height with proper nutrition to different *utera* crop was the indication of better internode elongation and good vegetative growth throughout the crop cycle.

Total dry matter production increased gradually with the advancement of crop age and reached its peak at the time of harvest. Among the *utera* crops linseed, lentil and lathyrus, dry

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matter accumulation increased progressively with the advancement of crop growth and their variations were due to crop nutrition.

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Table 3. Effect of fertilizer management on growth parameters of *utera* crops in rice fallows (pooled data)

Treatments	Plant height at harvest (cm)	TDM at harvest (g/m^2)	CGR at 60-harvest ($g/m^2/day$)	Branching at flowering	Nodule plant^{-1} at flowering
Utera crop					
Linseed	61.9	209.9	2.03	6.3	0.00
Lentil	45.0	256.4	2.32	8.4	24.8
Lathyrus	51.1	288.8	3.18	6.6	26.0
S.Em(±)	0.65	1.15	0.09	0.05	0.05
CD(*P*=0.05)	2.42	4.63	0.37	0.21	0.19
Crop Nutrition					
Suphala	54.8	243.8	3.19	7.5	17.8
DAPSoil	53.8	254.2	3.32	6.5	18.7
DAPSpray	49.5	257.1	2.80	7.3	14.3
S.Em(±)	0.34	1.15	0.14	0.13	0.07
CD(*P*=0.05)	1.07	3.59	0.44	0.39	0.23

TDM-Total dry matter; CGR-Crop growth rate

At harvest dry matter production among the *utera* crops like linseed, lentil and lathyrus varied to 209.9 to 288.8 gm^{-2} with 37.58% variation, the highest dry matter production (288.8 gm^{-2}) in lathyrus was recorded. In the experiment, *utera* crops fertilized with DAP foliar spray recorded the highest dry matter

Production of 257.1 gm^{-2} followed by DAP Soil (NP18:46) 254.2 gm^{-2} andtheleastvalueofdrymatter production 243.8 g m^{-2} was recorded under Suphala (NPK 15:15:15). Application of foliar nutrition at later stage was helpful for the plants to grow and produce higher amount dry matter.

The dry matter partitioning of crop growth with time in terms of crop growth rate (CGR) of utera crops was significantly influenced by the different nutrient management practices (Table 3). Although the CGR was slow during early initial stage (just after sowing), thereafter increased progressively with the increase in crop age upto active vegetative and reproductive stage (Table 3). At 60 DAS to harvest CGR-value of utera crops varied from 2.03 to 3.18 g m^{-2} day^{-1}with 56.65 % variation

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and the highest crop growth rate value found in lathyrus (3.18gm^{-2}day^{-1}).In the experiment *utera* crops fertilized with DAP (NP18:46) recorded the highest CGR value 3.32g m^{-2}day^{-1}followed by Suphala (NPK15:15:15) 3.19gm^{-2} day^{-1}.

The production of branches in *utera* crops like linseed, lentil and lathyrus at flowering time varied significantly with the variation of different nutritional management practices (Table 3). At flowering time number of primary branches of crop varied from 6.3 to 8.4 with 33.33% variation and more number of branches (8.4) in lentil crop and less number of secondary branches (6.3) in linseed were seen (Table 3). In the experiment *utera* crops fertilized with Suphala recorded the more number of secondary branches (7.5) followed by DAP-spray 7.3 and the less n umber of secondary branches (6.5) were recorded under DAP (NP 18:46).

Active nodule number at flowering stage of crop growth was significantly influenced by the different nutritional management practices (Table 3).Variations due to crop nutrition were much noted at the flower initial to 50% flowering stage after flowering nodule number continuously decreases. Among the *paira* crops like lentil and lathyrus, the nodule numbers per plant at the flowering stage varied from 24.8 to 26.0 respectively and the more number of nodules per plant recorded in lathyrus (26.0). In the experiment, *utera* crops fertilized with DAP (NP 18:46) recorded the more nodules per plant (18.7) followed by Suphala (NPK15:15:15) 17.8 and the least number of nodule per plant (14.3) was recorded under DAP spray treatment.

Effecton yield attributes and yield

There was significant effect on yield attributes and yield of *utera* crops under different nutrient management practices (Table 4). Plant population at harvest, an important parameter in *utera* crops, was significantly influenced by nutrient management in lowland rice ecosystem (Table 4). Maximum plant population was in 49.7 to the tune of 16.06% per m^2 and the least was in 42.8per m^2.Crop nutrition with DAP soil fertilizer in *utera* crops had a distinctive impact on population. Maximum plant population was noted with Suphala fertilizer management in lathyrus crop.

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The number of pods plant^{-1} of *utera* crops like linseed, lentil and lathyrus in rice ecosystem was significantly influenced by the nutrient management practices (Table 4). Among the *utera* crops lentil recorded the highest number of pods plant^{-1} (27.1) followed by lathyrus (25.4) but linseed crop gave the lowest number of pods plant^{-1}(8.7). In the experiment, *utera* crops fertilized with Suphala recorded the highest number of pods plant^{-1} (21.6) followed by DAP-soil (20.5) and the lowest number of pods plant^{-1} (19.0) was recorded in DAP-spray.

Table4. Effect of fertilizer management on yield attributes and yield of *utera* crops in rice fallows (pooled data)

Treatments	Plant population at harvest	No. of pods plant^{-1}	Seeds pod^{-1}	10 pod weight (g)	Test weight (g)	Seed yield (kgha^{-1})	Biomass yield (kgha^{-1})	Harvest Index
Utera crop								
Linseed	42.8	8.7	6.9	0.55	5.3	404	1508	0.27
Lentil	49.0	27.1	2.1	2.37	20.9	721	1970	0.37
Lathyrus	49.7	25.4	4.0	2.03	59.1	725	2481	0.29
S.Em(±)	0.16	0.28	0.27	0.11	0.67	9.22	9.36	0.05
CD(*P*=0.05)	0.63	1.15	1.10	0.44	2.69	37.17	37.73	0.19
Crop Nutrition								
Suphala	49.6	21.6	5.0	1.86	30.2	650	1910	0.29
DAPSoil	49.8	20.5	4.2	1.71	28.6	634	1965	0.25
DAPSpray	42.1	19.0	3.9	1.38	26.5	566	2084	0.26
S.Em(±)	0.21	0.58	0.136	0.10	0.34	14.73	7.94	0.007
CD(*P*=0.05)	0.64	1.83	0.423	0.31	1.04	45.91	24.74	0.023

The number of seeds per pod of *utera* crops also significantly influenced by the nutrient management practices (Table 4). Among the *utera* crops, linseed recorded the highest number of seeds pod^{-1} of 6.9 followed by lathyrus (4.1) but lentil crop gave very less number of seeds pod^{-1} of 2.1 seeds pod^{-1}. In the experiment, *utera* crops fertilized with Suphala recorded the highest number of seeds per pod (5.1) followed by DAP-soil (NP 18:46) the treatment (4.2) and the

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lowest number of seeds per pod (3.9) was recorded in DAP-spray treatment. Seeds per pod were not more influenced by nutrient management it varies from crop to crop. Linseed is a small seeded oilseed crop that produced more number of seed per pod than lathyrus and lentil.

The 10-pod weight of *utera* crops like linseed, lentil and lathyrus in rice ecosystem was significantly influenced by the nutrient management practices (Table 4).Among the *utera* crops, lentil recorded the highest pod weight of 2.37 g followed by lathyrus (2.03 g) but linseed crop gave very less (0.55g). In the experiment, *utera* crops fertilized with Suphala (NPK15:15:15) recorded the highest 10-

pod weight (1.86 g) followed by DAP (NP 18:46) soil application and the lowest pod weight (1.38 g) was recorded in DAP foliar spray treatment.

The plumpness or boldness of seed in terms of test weight (1000 grain weight) of *utera* crops grown under diversified nutrient management was found significant. Among the *utera* crops, lathyrus recorded the maximum test weight of (59.1) followed by lentil (20.9) but linseed crop gave very less test weight (5.3). In the experiment, *utera* crops fertilized with Suphala (NPK15:15:15) recorded the highest test weight (30.2) followed by DAP (NP 18:46) the treatment (28.6) and the lowest test weight was recorded in DAP spray (26.5).

The land productivity in terms of seed yield of *utera* crops like linseed, lentil and lathyrus grown in rice ecosystem was significantly influenced by the nutrient management practices (Table 4). Among the *utera* crops, lathyrus recorded the highest yield of 725 kg ha^{-1}followed by lentil (721 kg ha^{-1}) but linseed crop gave very less yield of 404 kg ha^{-1}. In harmony to our findings, Bandyo padhyay *etal.* (2018) also reported that higher yield of lentil was obtained in no tillage condition then conservation and minimum tillage condition. The yield variation among the utera crops was 79.45%. In the experiment, *utera* crops fertilized with Suphala (NPK15:15:15) @ 150 kg ha^{-1} recorded the highest grain yield (650 kg ha^{-1}) followed by DAP (NP 18:46) @ 125 kg ha^{-1} and the lowest seed yield (565.83 kg ha^{-1}) was recorded in DAP foliar spray treatment. The yield variation due to differential nutrition was 14.85% which was much less under zero-till situation.

Interaction effects of *utera* crops with different fertilizer management on

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seed yields and their yield attributes were significantly noted but not shown here. The seed yield of linseed cv Neela varied to the tune of 10.44 to 39.93% by the differential nutrient gradation. Similarly, lentil and lathrus recorded yield variation of 28.73 to 39.41% and 12.04 to 14.91% respectively. Among the fertilizer sources, Suphala was found most effective in lathyrus and linseed and similarly DAP in lentil on the basis of their yield performances. DAP foliar spray gave always least yield in these three *utera* crops.

The biomass productivity in terms of strover plus seed yield of *utera* crops like linseed, lentil and lathyrus in rice ecosystem was significantly in fluenced by the nutrient management practices (Table 4). Among the *utera* crops, lathyrus recorded the highest biomass yield of 2481 kg ha^{-1} followed by lentil (1970 kg ha^{-1}) but linseed crop gave very less biomass yield of 1508 kg ha^{-1}. In the experiment, *utera*crops fertilized with DAP foliar spray recorded the highest biomass yield (2084 kg ha^{-1}) followed by DAP (NP 18:46) the treatment (1965 kg ha^{-1}) and the lowest biomass yield (1909 kg ha^{-1})was recorded in Suphala treatment.

The source to sink ratio in terms of harvest index of *utera* crops like linseed, lentil and lathyrus in rice ecosystem was significantly influenced by the nutrient management practices(Table4).Among the

Utera crops, lentil recorded the highest harvest index of 0.37 followed by lathyrus (0.29) but linseed crop gave very less harvest index of 0.27. In the experiment, utera crops fertilized with Suphala (NPK 15:15:15) recorded the highest harvest index (0.29) followed by DAP spray the treatment (0.26) and the lowest harvest index (0.25) was recorded in DAP (NP 18:46) treatment.

Effect on available nutrients status in post-harvest soil

Data related with available nutrients in soil after harvest of crop are presented in (Table 5).The status of available N, P, K, and organic C in soil was significantly influenced by different nutrient management. Among the *utera* crops linseed lentil and lathyrus the results revealed that N, P and K and organic carbon content differ significantly.

Table5. Effect of fertilizer management on nutrient status in post-harvest soil of utera crops in rainfed rice fallows (pooled data)

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Treatment	Nutrient status in post-harvest soil			
	Nitrogen ($kgha^{-1}$)	Phosphorus ($kg\ ha^{-1}$)	Potassium ($kg\ ha^{-1}$)	Carbon (%)
Utera crop				
Linseed	190.2	28.8	194.0	0.56
Lentil	227.9	42.2	207.4	0.65
Lathyrus	225.5	38.7	200.2	0.63
S.Em(±)	0.019	0.114	0.058	0.001
CD(*P*=0.05)	0.075	0.458	0.234	0.005
Crop Nutrition				
Suphala	216.8	35.2	228.5	0.62
DAPSoil	234.7	42.1	189.6	0.66
DAPSpray	192.23	32.5	183.6	0.61
S.Em(±)	0.028	0.141	0.043	0.003
CD(*P*=0.05)	0.087	0.438	0.135	0.009

Maximum content of available nitrogen, phosphorus, potassium and organic carbon % was noted under lentil crop grown field i.e. (227.9 kg ha^{-1}, 42.3 kg ha^{-1}, 207.4kg ha^{-1} and 0.65) followed by lathyrus grown field i.e. (225.5 kg ha^{-1}, 38.8 kg ha^{-1}, 200.2 kg ha^{-1} and 0.63) but linseed grown field gave less available nutrient status i.e.(190.2 kg ha^{-1}, 28.8 kg ha^{-1}, 194.0 kg ha^{-1} and 0.56). Among the different nutrient management practices available nitrogen, phosphorus and % of organic carbon were found maximum in the plot fertilized with DAP (NP18:46) soil application i.e.(234.7 kg ha^{-1},42.1kg $ha^{-1}$and 0.66%) and potassium status highest in the plot fertilized with Suphala (NPK15:15:15)i.e.(228.5kg ha^{-1}). Lowest nutrient status was recorded under only DAP foliar spray treatment.

Effects on actual evapo transpiration, water use efficiency and soil moisture extraction

The variation in actual evapo transpitation (ETa) of *utera* crops was much influenced in no-till rice ecosystem (Table6).Lathyrus crop with huge ground coverage has the lowest ET a value (133.8mm)

whereas, linseed crop characterised by deep root and less ground cover recorded highest water uptake showing ETa value of 182.0 mm. The variation of ETa was about 36.02% and this variation might be attributed to their variation in canopy

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cover and water extraction differences. Fertilizer application of DAP soil registered the highest ETa value of 187.7 followed by Suphala (156.5mm) and the least Eta was seen in DAP spray. Here, variation in ETa was noted up to 19.93% which might be caused by their nutrient mining capacity in utera cropping situation.

Table 6. Effect of fertilizer management on actual evapo transpiration(ETa) and water use efficiency (WUE) of utera crops in rainfed rice fallows (mean values of 2 years)

Treatment	ETa (mm)	Yield ($kgha^{-1}$)	WUE ($kgha\text{-}mm^{-1}$)
Utera crop			
Linseed	182.0	440	2.42
Lentil	157.4	721	4.58
Lathyrus	133.8	725	5.42
Crop nutrition			
Suphala	156.5	650	4.15
DAPSoil	178.7	634	3.55
DAPSpray	138.1	566	4.10

The water use efficiency (WUE) of *utera* crops like linseed,lentil and lathyrus in rice ecosystem was much influenced by the nutrient management practices (Table 6). The WUE of linseed cv Neela recorded2.42kg/ha-mm and the highest WUE value was achieved by Lathyrus (5.42kg/ha-mm and the variation was more than double (124%) in no-till rice ecosystem. The differential nutrient nutrient feeding of utera crops created narrow variation (16.91%) in WUE value. Among the fertilizer sources, Suphala was found most effective followed by DAP foliar spray on the basis of their WUE. DAP foliar spray gave always least yield in these three *utera* crops. Crop WUE was more in lathyrus and least value was noted in linseed.

The soil moisture extraction pattern of utera crops like linseed, lentil and lathyrus was very much influenced by crop nutrition sources (Figure 1). *Utera* crops were sown on the saturated paddy soils in standing rice 10 days before harvest of the crop with the soil moisture content. Fertilizers like Suphala and DAP were applied 4 days before seed sowing of crops. The soil moisture varied from 38.84 to 41.99% at seed sowing stage and at the harvest of the utera crops soil moisture varied from

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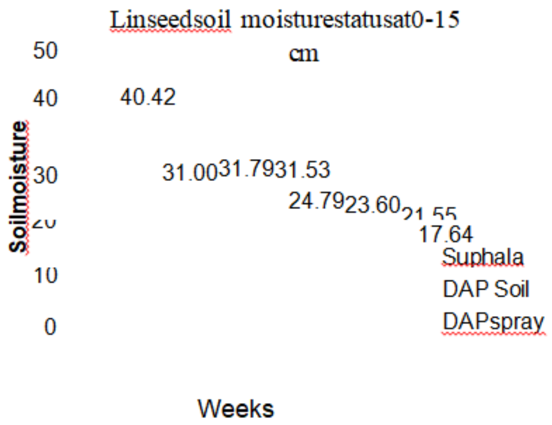
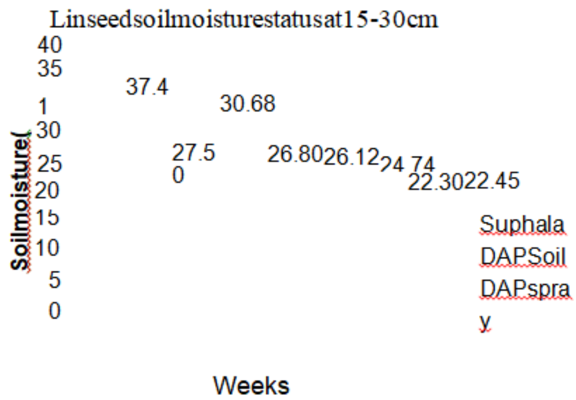
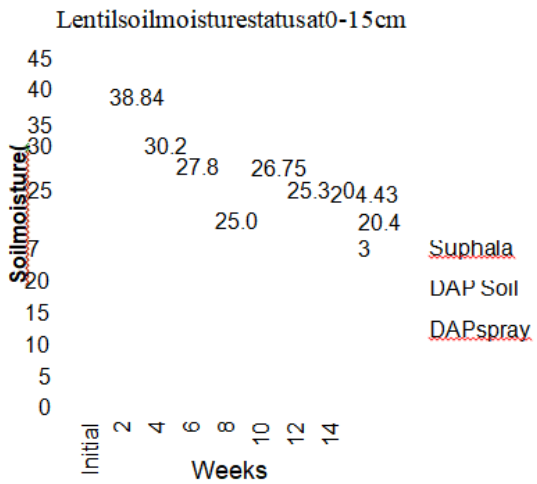
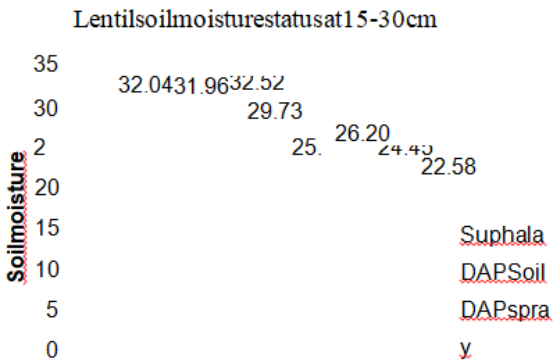
17.64 to 18.25 at 0-15 cm soil depth and at lower depth of soil (15-30cm) soil moisture was from 22.45 to 25.41% depending on the type of crops.









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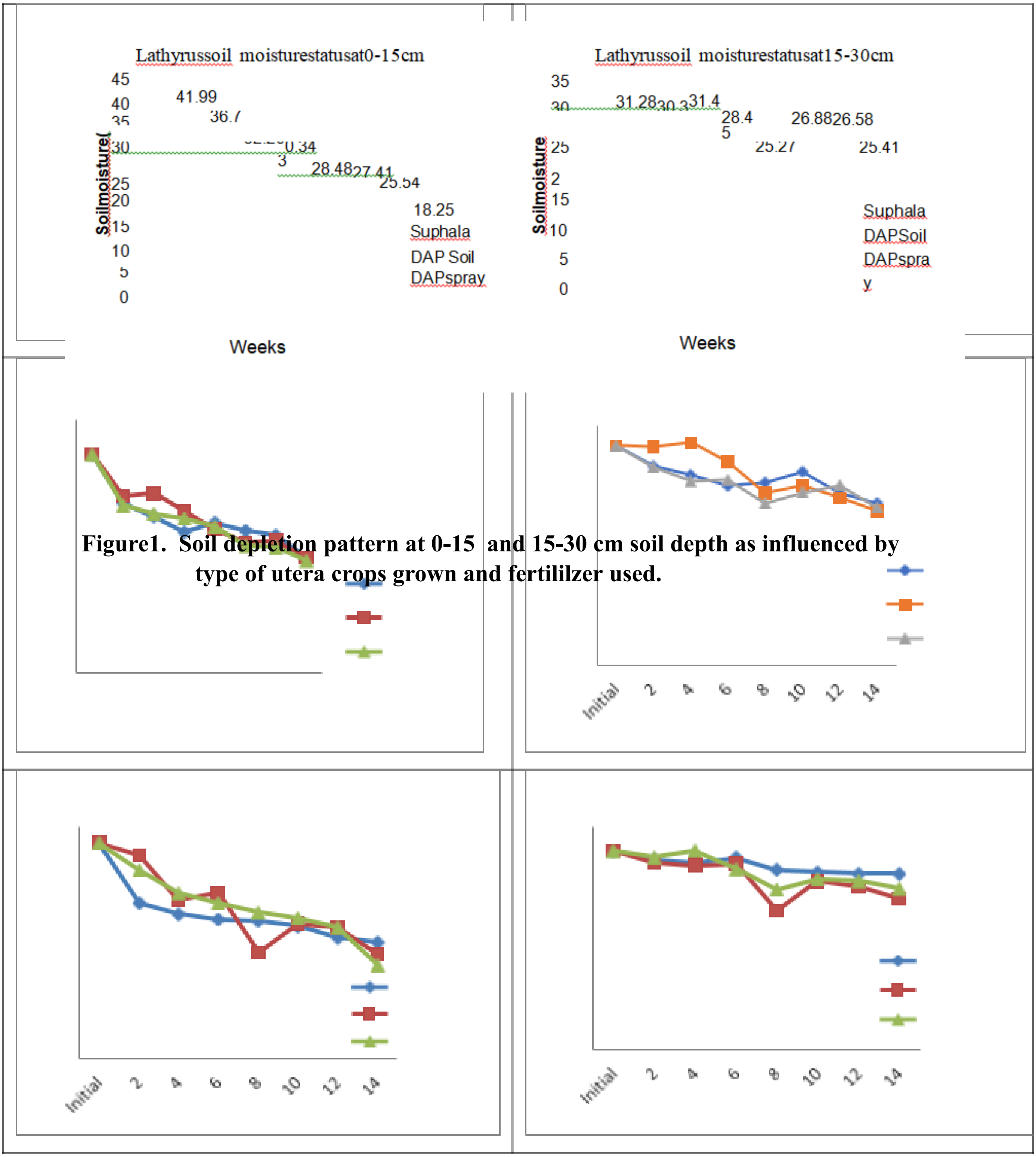

Figure1. Soil depletion pattern at 0-15 and 15-30 cm soil depth as influenced by type of utera crops grown and fertililzer used.

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Lentil crop depleted more soil moisture than lentil and lathyrus. Regarding fertilizer sources, soil moisture depletion was more by the Suphala (NPK15:15:15) than DAP (NP18:46). DAP spray had little impact on soil moisture extraction. Soil moisture extraction differentiation was more pronounced at flowering to pod development (6-12 weeks) of utera crops. At harvest linseed crop recorded less soil moisture content of 17.54% at top layer (0-15 cm).

Production economics of utera crops

More acceptability of any research finding among small and marginal farmers depends on its economic viability. Economics of *utera* crops linseed, lentil and lathyrus production in terms of gross return and net return and benefit: cost ratio was calculated for different mode of nutrient treatments and data are presented in (Table7). It is evident from the tables that lentil crop had the highest net return of Rs.23024 per ha with the highest benefit-cost ratio of2.73 followed by lathyrus.The direct effect of fertilizer management on production economics was more pronounced in Suphala and DAP soil application than DAP spray. The combined effect so future crop and fertilizer application were studied as in case lentil with DAP (NP18:46) treatment combination (C_2N_2) recorded the highest gross return of Rs.40836/- and the lowest gross return of Rs.14793/- recorded under linseed with DAP (NP 18:46) foliar spray treatment combination (C_1N_3). In case of the net return among the *paira* crop so flinseed, lentil and lathyrus observed that net return of lentil with DAP (NP 18:46) treatment (C_2N_2) combination had the highest net return RS.27380/- recorded. But in linseed with DAP (NP 18:46) treatment (C_1N_2) combination was recorded the lowest net return RS.4316/-. Under same treatment combinations recorded highest benefit-cost ratio of 3.03 i.e. in lentil with DAP soil application (C_2N_2) treatment combination. In case of linseed with DAP (NP18:46) soil application recorded minimum benefit cost ratio (1.36) was observed.

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Table7. Effect of fertilizer management on production economics of utera crops in rainfed rice follows (mean values of 2 years)

Treatment	Cost (Rs.ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs.ha^{-1})	B:C
Utera crop(C)				
Linseed(C_1)	11320	17151	5831	1.51
Lentil(C_2)	13374	36398	23024	2.73
Lathyrus(C_3)	12571	30223	17652	2.40
Crop nutrition(N)				
Suphala(N_1)	12807	29536	16728	2.29
DAPSoil (N2)	12586	28663	16077	2.25
DAPSpray(N_3)	11872	25573	13701	2.10
Interaction effect				
C_1N_1	11756	20249	8493	1.72
C_1N_2	12096	16412	4316	1.36
C_1N_3	10110	14793	4683	1.46
C_2N_1	13706	29841	16135	2.18
C_2N_2	13456	40836	27380	3.03
C_2N_3	12960	38517	25557	2.97
C_3N_1	12206	28742	16536	2.35
C_3N_2	12546	23410	10864	1.87
C_3N_3	10560	20525	9965	1.94

Conclusion

Considering the results of the experiment in rainfed rice fallows of lower Indo-Gangetic Plains, it may be advocated that linseed and lathyrus may be grown with the fertilizer Suphala (15:15:15) @ 150 kg ha^{-1} but for lentil crop may be grown with Di-ammonium Phosphate (18:46) @ 125 kg ha^{-1}. The maximum benefit cost ratio (3.03) was obtained in lentil with DAP soil application in the alluvial soils in the Gangetic plains.

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Research Article

Influence of Weed Management and Phosphorus Fertilization on Yield Attributes and Economics of Cowpea [*Vignaunguiculata* (L.) Walp.]

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Abstract

A field experimentation was conducted during *kharif* 2019 at Instructional Farm of Agronomy, Rajasthan College of Agriculture, Udaipur to study theeffect of weed management and phosphorus fertilization on weeds and productivity of cowpea. Results shown that all the yield attributes significantly influenced by all the weed control treatments compared to weedy check. The highest number of seeds pod^{-1}, length of pod, pod yield plant^{-1} and weight of 100 seeds were documented with weed free treatment which was statistically at par with pendimethalin 750 g ha^{-1}as pre-emergence in combination with imazethapyr + imazamox 33.75 g ha^{-1} as post-emergence. With regard to net returns and B-C ratio are concerned, the highest net returns and B-C ratio was obtained with pendimethalin750 g ha^{-1} as pre-emergence in conjugation with imazethapyr + imazamox33.75 g ha^{-1} as post-emergence which was statistically at par with pendimethalin1000 g ha^{-1} along with HW at 15-20 DAS in terms of net returns and with imazethapyr + imazamox45 g ha^{-1} in terms of B-C ratio.

Yield attributes like number of seeds pod^{-1}, length of pod, pod yield plant^{-1} and 100 seed weight pointedly increased with application of phosphorus at 40 kg P_2O_5 ha^{-1} compared to 30 kg P_2O_5 ha^{-1} at significant level and further addition of phosphorus from 40 to 50 kg P_2O_5 ha^{-1} failed to bring any significant improvement in these parameters. Application of 40 kg P_2O_5 ha^{-1} significantly enhanced net returns and B-C ratio of cowpea over 30 kg P_2O_5 ha^{-1} and further addition of phosphorus from 40 to 50 kg P_2O_5 ha^{-1} failed to enhance this parameter significantly.

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Keywords: Cowpea, Yield attributes, Phosphorus fertilization, Economics of Cowpea

Introduction

Cowpea is known for its versatile utilities *viz*., grain, forage, cover/smother crop and green manure crop. Leguminous pulses are renowned for their exceptional nutritional value and delightful taste. Beyond their role as a dietary staple, these pulses contribute significantly to agricultural sustainability through their unique ability to fix nitrogen (Abayomi and Abidoye, 2009). The productivity of the crop in Rajasthan is low and far below than its yield potential. This disparity is primarily attributed to inadequate weed management practices and insufficient nutritional support, particularly in terms of phosphorus fertilization.The unchecked growth of weeds in the rainy season poses a serious threat to crop thereby drastic reduction in crop yield.

The scarcity of labor and challenging soil conditions renders manual weeding less effective and efficient, especially during critical periods. Consequently, herbicidal weed control has emerged as a predominant solution in contemporary agricultural practices. However, the effectiveness of herbicides necessitates detailed studies focusing on their selectivity concerning specific crops. In addition, acknowledging the pivotal role of phosphorus in influencing root growth, nodule development, bacterial activity, and nitrogen fixation, its application becomes indispensable for achieving a profitable yield. In light of these considerations; a field study was designed with the primary objective of investigating the impact of weed management and phosphorus nutrition on the yield of cowpea.

Materials and Methods

The experiment was conducted during *kharif*2019 at Instructional Agronomy Farm of Rajasthan College of Agriculture, MPUAT, Udaipur. The soil of the experimental site was clay loam in texture with 288.00, 20.54 and 286.92 kg ha^{-1} available nitrogen, phosphorus and potassium, respectively, in 0-30 cm soil depth with pH 8.19. The experiment was laidin factorial randomized block design with three replications and constituting 18 treatment

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combinations consisting of 6 weed control treatments (Pendimethalin 1000 g ha^{-1} PE *fb* hoeing and weeding 15-20 DAS, imazamox + imazethapyr 45 g ha^{-1} at 15-20 DAS, pendimethalin 750g ha^{-1} PE *fb*imazamox + imazethapyr 33.75 g ha^{-1} at15-20 DAS, one hoeing and weeding 15-20 DAS, weed free up to 50 days and weedy check) and 3 phosphorus levels (30, 40 and 50 kg P_2O_5 ha^{-1}). As per treatments, the needed quantities of fertilizers were applied below the seed at the time of sowing. Cowpea variety RC-101 was used as test crop with seed rate 15 kg ha^{-1} with recommended package of practices.

Results and Discussion

Yield attributes

An examination of data (Table 1) implies that all the weed management treatments significantly improved number of seeds pod^{-1}, length of pod and pod yield $plant^{-1}$, weight of 100 seeds were consistently higher by all the weed management treatments except weedy check. The highest number of seeds pod^{-1} was observed with pendimethalin 750 g ha^{-1} as pre-emergence in combination with imazethapyr + imazamox 33.75 g ha^{-1} as post-emergence (7.30). Weed free treatment (13.91 cm) was found superior in terms of length of pod which was statistically at par with pendimethalin 750 g ha^{-1} as pre-emergence in combination with imazethapyr + imazamox 33.75 g ha^{-1} as post-emergence (13.31 cm) and pendimethalin 1000 g ha^{-1}*fb* hoeing and weeding at 15-20 DAS (13.23 cm). The lowest length of the pod was observed with weedy check (10.73 cm). The highest pod yield $plant^{-1}$ was obtained with weed free treatment (7.18 g) which was statistically at equivalence with pendimethalin 750 g ha^{-1} as pre-emergence in conjugation with imazethapyr + imazamox 33.75 g ha^{-1} as post-emergence (6.86 g) and pendimethalin 1000 g ha^{-1} along with hoeing and weeding at 15-20 DAS (6.82 g). Weed free treatment (8.16 g) caused the highest weight of 100 seeds which was statistically comparable with pendimethalin 750 g ha^{-1} as pre-emergence along with imazethapyr + imazamox 33.75 g ha^{-1} as post-emergence (8.08 g) and pendimethalin 1000 g ha^{-1} accompanied by hoeing and weeding at 15-20 DAS (7.93 g). It can be described in the light of realities that these treatments controlled the weeds effectively, might have made more nutrients, space and soil moisture available to crop and thus enhanced seed and haulm yield of cowpea. This can be further explained on the basis of facts that these

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treatments remarkably controlled weeds in this way showing the highest weed control efficiency and documented the lowest weed index thus improving seed yield of cowpea. These results coincide with the results recorded by Rao *et al*. (2010), Choudhary*et al*. (2014).

Application of phosphorus did not increase number of seeds pod^{-1}and weight of 100 seeds of cowpea significantly as it is clear from data presented in Table 1. Addition of phosphorus at 40 kg P_2O_5 ha^{-1} significantly influenced length of pod of cowpea over 30 kg P_2O_5 ha^{-1}. Analysis of data further indicates that additional increase in the phosphorus by 10 kg failed to enhance this parameter considerably. Application of phosphorus at 40 kg P_2O_5 ha^{-1}influentially increased pod yield plant^{-1} over 30 kg P_2O_5 ha^{-1} by 0.71 g plant^{-1}. It is also evident from the data that further increase in the phosphorus by 10 kg failed to improve pod yield plant^{-1} considerably. This might be ascribed to enhancement both in growth and yield attributes. Adequate phosphorus levels boost vigorous root and shoot growth thus increased seed yield. The overall improvement in all these parameters owing to phosphorus nutrition appears to be due to its indispensable role in photosynthesis, pod development and grain filling in leguminous crops. It is accountable for nodulation in cowpea, thus higher nodulation resulted in higher nitrogen fixation and eventually the number of pods plant^{-1} and seed yield. These results substantiate findings of Singh *et al*. (2011).

Economics

Data pertaining to net returns and B-C ratio of cowpea under the influence of weed management treatments presented in Table 2 reveal that all the weed management treatments considerably increased these parameters over weedy check plot. The highest net returns of ₹ 39,737 ha^{-1} was obtained with pendimethalin750 g ha^{-1} as pre-emergence in conjugation with imazethapyr + imazamox 33.75 g ha^{-1} as post-emergence which was statistically at par with pendimethalin 1000 g ha^{-1} along with hoeing and weeding at 15-20 DAS (₹ 36,994 ha^{-1}). Maximum B-C ratio was obtained under pre-emergence application of pendimethalin 750 g ha^{-1} accompanied by post-emergence application of imazethapyr + imazamox 33.75 g ha^{-1} at 15-20 DAS (2.04) which was statistically at par with imazethapyr + imazamox 45 g ha^{-1} (1.90). On account of higher yield and relatively lower cost of pendimethalin 750 g ha^{-1} as pre-emergence in conjugation with imazethapyr + imazamox 33.75 g ha^{-1} documented maximum B-C ratio (2.04) compared to other treatments.

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Application of phosphorus at 40 kg P_2O_5 ha^{-1} significantly enhanced net returns of cowpea over 30 kg P_2O_5 ha^{-1} by ₹ 5566 ha^{-1}. It is also clear from the data that further addition of phosphorus from 40 to 50 kg P_2O_5 ha^{-1} failed to enhance this parameter significantly. Application of phosphorus at 40 kg P_2O_5 ha^{-1}significantly increased B-C ratio of cowpea over 30 kg P_2O_5 ha^{-1}. It is also apparent from the data that further addition of phosphorus from 40 to 50 kg P_2O_5 ha^{-1} failed to enhance this parameter significantly.

Conclusion

After weed free treatment, pre-emergence application of pendimethalin 750 g ha^{-1} accompanied by post-emergence application of imazethapyr + imazamox 33.75 g ha^{-1} at 15-20 DAS in cowpea recorded significantly higher yield attributes while application of 40 kg P_2O_5 ha^{-1} documented significantly higher yield attributes of cowpea.The highest net returns and B-C ratio of cowpea was obtained with pendimethalin750 g ha^{-1} as pre-emergence in conjugation with imazethapyr + imazamox 33.75 g ha^{-1} as post-emergence over all weed management treatments.

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Table 1: Effect of weed management and phosphorus levels on yield attributes of cowpea

Treatments	No. of seeds pod^{-1}	Length of pod (cm)	Pod yield plant^{-1} (g)	Weight of 100 seeds (g)
Weed management				
Pendimethalin 1000 g PE *fb* HW	7.05	13.23	6.82	7.93
Imazethapyr + imazamox 45 g	7.00	12.19	6.28	7.80
Pendimethalin 750 g PE *fb*imazethapyr + imazamox 33.75 g	7.30	13.31	6.86	8.08
One hoeing and weeding 15-20 DAS	6.91	12.05	6.22	7.75
Weed free (up to 50 days)	7.26	13.91	7.18	8.16
Weedy check	6.08	10.73	3.00	7.36
SEm±	0.09	0.27	0.14	0.09
CD(P= 0.05)	0.27	0.76	0.40	0.26
Phosphorus levels (P_2O_5 kg ha^{-1})				
30	6.92	11.40	5.45	7.78
40	6.93	12.78	6.16	7.81
50	6.95	13.53	6.57	7.95
SEm±	0.13	0.38	0.20	0.13
CD(P= 0.05)	NS	1.09	0.58	NS

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Table 2: Effect of weed management and phosphorus levels on economics of cowpea

Treatments	Net return (₹ ha^{-1})	B:C ratio
Weed management		
Pendimethalin 1000 g PE *fb* HW	36,994	1.69
Imazethapyr + imazamox 45 g	35,571	1.90
Pendimethalin 750 g PE *fb*imazethapyr + imazamox 33.75 g	39,737	2.04
One hoeing and weeding 15-20 DAS	32,282	1.51
Weed free (up to 50 days)	35,572	1.35
Weedy check	8,302	0.47
SEm±	1225	0.03
CD(P= 0.05)	3494	0.17
Phosphorus levels (P_2O_5 kg ha^{-1})		
30	26,697	1.30
40	32,263	1.53
50	35,268	1.64
SEm±	1733	0.08
CD(P= 0.05)	4979	0.22

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Impact of Organic Manures On Physical, Chemical, And Biological Properties 0f Soil

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Abstract

The sustainable management of soil health is critical for agricultural productivity and environmental conservation. This study investigates the influence of organic manures on the physical, chemical, and biological properties of soil, aiming to enhance our understanding of their impact on soil quality. The research employs a comprehensive approach, analyzing the effects of various organic manures on soil texture, structure, and moisture retention. Additionally, the study assesses changes in soil chemical properties, including nutrient levels, pH, and cation exchange capacity, to elucidate the role of organic inputs in nutrient cycling and availability. Furthermore, the investigation delves into the dynamic interplay between organic manures and soil microorganisms, evaluating microbial abundance, diversity, and activity. The study aims to unravel the intricate relationships between organic amendments and soil biota, shedding light on their potential contributions to soil fertility and ecosystem resilience.By synthesizing data from field experiments and laboratory analyses, this research aims to provide valuable insights into the sustainable use of organic manures for soil management. The findings are expected to contribute to the development of eco-friendly agricultural practices that optimize soil health, promote crop productivity, and minimize environmental impacts. This research holds significance for farmers, policymakers, and researchers seeking to advance sustainable agriculture and soil conservation practices.

Key words: Organic manures, Soil health, Sustainable agriculture, Cation exchange capacity, Soil fertility, Ecosystem resilience, Eco-friendly agriculture

Introduction

After 50 years of the green revolution, the continuous trend of application of fertilizers in an imbalanced way because of unawareness of the farmers, improper agricultural extension education, and some govt. policies like subsidy on urea NBS (nutrient-based

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subsidy) led to the emergence of water bodies' pollution by nitrate and soil health degradation. As a result, the economic efficiency of fertilizer use as well as the quality of crop products deteriorated. According to all India data, fertilizer consumption rates in 2021 were 137.150 kg/ha which is higher than the previous year's as 127.790 kg/ha.The production of food grains in the country is estimated at a record 314.51 million tonnes during 2021-22 which is higher by 1.21% than 2020-21. Now a day's a question arises about soil health which is day by day deteriorating (multi-nutrient deficiency) due to excessive and unorganized use of primary fertilizers like urea and DAP only. To overcome this problems, we have to integrate these fertilizers along with organic manures like FYM, compost, vermicompost, enriched compost and biofertilizers. So instead of conventional chemical use, the trend is moving towards organic farming.

On Farm Availability and Losses

In India, on-farm residues like straw and garden wastes are not recycled. A great amount of straw is used for feeding cattle. In the case of urine and cow dung, none of them are using scientific techniques for handling and preservation of cow dung and urine. Most of the dung is used for household fuel in the rural areas and this way decreasing the use of cow dung as farm input. Urine containing high amounts of nitrogen and potassium is significantly lost into the environment by means of leaching or volatilization losses this way a great decrease amount of nutrients in farm yard manure and composed observed.

Types of Organic Manures and their Uses

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1. FYM (Farm Yard Manure):-FYM is prepared by farmers on their farm and is of very low quality and has a low amount of nutrients, as they are not following scientific techniques for preserving urine and dung. On average well decomposed farmyard manure contains 0.5 percent N 0.2 percent P_2O_5 and 0.5 percent K_2O.

Improved Method for Preparation of FYM: The_Trench method of preparing FYM advocated by **C.N. Acharya** is found one of the best methods for preparing FYM. All available dry litter and refuse from the farm and the houses should be heaped up near the cattle shed and portions of litter mixed with earth if available should be spread in the shed in the evening at 2.26 kg per animal for the absorption of urine. Chemical preservatives like gypsum, and rock phosphate are added to reduce losses and enrich FYM. Bacteria and actinomycetes play an active role in decomposition. Generally, 60-70 percent moisture in the initial stage and 30-40 percent moisture in decomposed manure (ready to use) as well as 50-60°C temperature under the heap are favourable for the activities of these micro-organisms. It is possible to prepare by this process 5 to 6 t of FYM per year per head of cattle.

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2. Compost: - The compost made from farm waste like sugarcane trash, paddy straw, weeds, and other plants and other waste is called farm compost. It uses all farm waste residues to form a valuable nutrient-rich compost. The N-P-K ratio of compost varies from 1.5-. 5-1 to 3.5-1-2. The compost made from town refuse like street sweepings and dustbin refuse is called **Town compost**. It contains 1.4 % N 1.0% P_2O_5 and 1.4 % K_2 O.

Composting is the natural process of 'rotting' or decomposition of organic matter such as crop residues, animal wastes, food garbage, etc. by micro-organisms under controlled conditions.

Methods of Composting

1. Bangalore Method (aerobic and anaerobic process): This process of composting was developed by Dr. C.N. Acharya in 1949. This process is called aerobic and anaerobic decomposition of compost. In this process, the basic raw material is not so well decomposed as in the other methods. But organic matter and nitrogen contents are well conserved. The number of turnings is reduced. The outturn of the compost is a relatively greater and cheapest process.

2. Indore Method (aerobic process) : This method of composting was developed by Ward and Howard. The waste materials such as plant residues, animal wastes, vegetable wastes, and weeds can be composted with the Indore Method. Under the aerobic process of decomposition,
losses of organic matter and nitrogen are heavy (40-50 percent at the initial stage). This process, however, involves considerable labour in the preparation of the heap and periodical turnings and so becomes expensive and impracticable when large quantities of materials are to be processed.

3.NADEP Compost (aerobic process): This method of composting was developed by farmer Narayan devraopandripande (also popularly known as NADEP kaka). Build a rectangular tank of 3 m length,2 m width and 1 m depth made of brick walls and floorwith mud plaster. Leave holes in the tank walls for aeration (about 4 holes along each side wall and two holes in each enclosure wall). Build a temporary shed of thatch and bamboo to shield compost tank

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from direct sunlight and rain. After 3-4 mon., digestion is complete and compost is ready having dark colour and pleasant smell. Sieve through a thick mesh and use the compost.

3. Enriched compost:-Enrich compost is a natural product made by composting recycled green materials such as garden cuttings, crop residues. Enrich compost is a great way of putting life back into poorly performing soil.

Enriched compost can be prepared by means of addition of fertilizer materials into compost. This way they are having varying amount of NPK content.

It is a soil improver which is suitable for mixing with soil but can also be used as topdressing, mulch or in "no-dig" approaches

4. Vermi compost:- The technique of breeding and raising earthworms in controlled conditions scientifically is called vermiculture, and making compost with the use of earthworms is called vermicomposting. Vermicompost is prepared by decomposition of organic material using various species of earthworms (*Eisenia foetida* and *Lumbricusrubellis*). Materials consumed by worms undergo physical breakdown in the gizzard resulting in particles of size < 2 μ, giving thereby an enhanced surface area for microbial processing. This finely ground material is exposedto various enzymes such as protease, lipase, amylase, cellulase and chitinase secreted into lumen by the gutwall and associated microbes. These enzymes breakdown complexbio-molecules into simple compounds. The earthworm assimilate 5-10 per cent of the substrate and rest passes through the alimentary canal and is excreted as cast. About 1,000 adult earthworms can convert 5 kg waste into compost per day. Theturnover of the compost is 75 percent of the total material accommodated in the pit, suppose 1,000 kg; the out turn will be 750 kg.

Vermicompost is rich in nitrogen 2-3%, potassium 1.85-2.25% and phosphorus 1.55-2.25% micronutrients, beneficial soil microbes and also contain plant growth hormones & enzymes. Vermicompost is a stable fine granular organic matter, when added to clay soil loosens the soil and provides the passage for the entry of air. The mucus associated with the cast being hygroscopic absorbs water and prevents water logging and improves water holding capacity. In the sandy soils where there is problem of water retention, the young strong mucus coated aggregates of vermicompost hold water for longer life.

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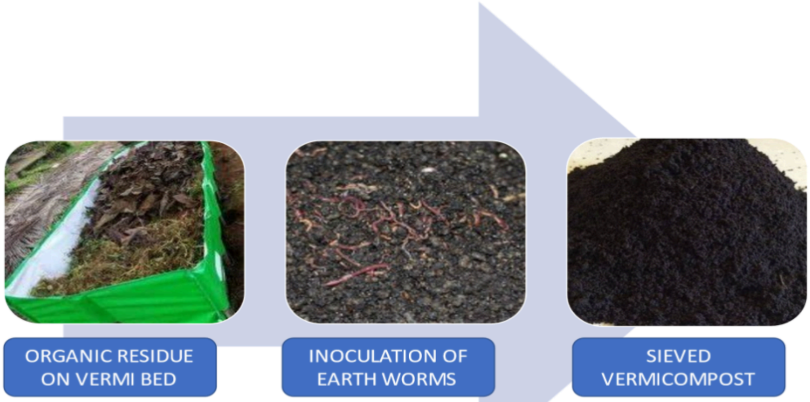

Fig : PROCESS OF VERMI COMPOST

5. Vermiwash liquid manure: collected after the passage of water through a column of worm action, very useful as a foliar spray to enhance the plant growth and yield and to check development of diseases. It is a collection of excretory products and mucus secretions of earthworm along with nutrients from the soil organic molecules.

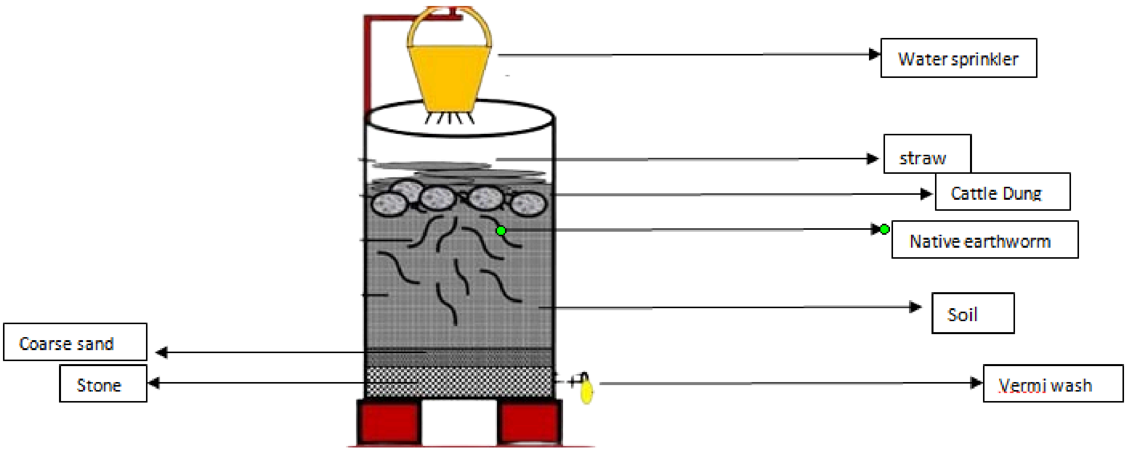

Fig:- VERMI WASH PROCESS

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6. Green manuring: Green manuring can be defined as a practice of ploughing or turning into the soil undecomposed green plant tissues for improving physical condition of soil as well as soil fertility.

Green Manuring In-situ: In this system green manure crops are grown and buried in the same field which is to be green-manured, either as a pure crop or as an intercrop with the main crop. Plants at the flowering stage contain the greatest bulk of succulent organic matter with a low carbon/ nitrogen ratio. Incorporation at this stage allows a quick liberation of nitrogen in the available form. Important green manure crops are Dhaincha, Sesbania, Sun hemp, Wild indigo, Indigo and Pillipesara.

Green Leaf Manuring: Green leaf manuring refers to turning into the soil green leaves and tender green twigs collected from shrubs and trees grown on bunds, waste lands and nearby forest areas.The common shrubs and trees used for green leaf manuring are *Glyricidiamaculata* (glyricidia), *Pongamia glabra* (Karaj), *Azadirachta indica (*neem) *Cassia auriculata* (Avaramsenna), *Thespesia populnea* (Portia tree) and *Ipomoea carnea* (Besharam).

7. Biofertilizer: -Biofertilizer are substance that contains microbes, which helps in promoting the growth of plants and trees by increasing the supply of essential nutrients to the plants. It comprises living and latent cells of organisms which include mycorrhiza fungi, blue-green algae, and bacteria.These microbes form either symbiotic relation with plants or living free into the soil and provide nutrients in available form to plants.Mostly used biofertilizer formulations are *rhizobium sp.* In *leguminacae* family. These bacteria form nodules in the roots of these plants and fixes atmospheric nitrogen.Another example of biofertilizer is PSB (phosphorus solubilizing bacteria) namely*, Pseudomonas, Bacillus, Micrococcus*, are helpful in increasing availability of phosphorus. Some fungi (*Aspergillus,Fusarium*) are also used for phosphorus mobilization and increasingavailability.

EFFECT OF ORGANIC MANURES:-

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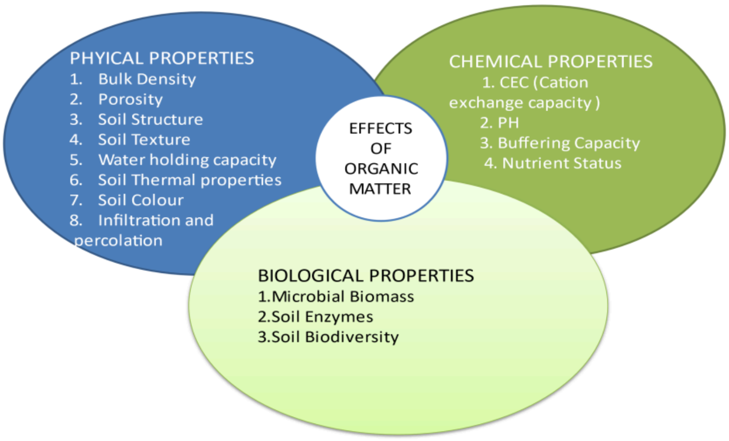

On Soil Physical properties

1. **Bulk Density**: - Since organic matter is lighter than an equal volume of solid soil and is more porous, hence a soil with higher organic matter will have lower bulk density.

2. **Porosity:** -They could have increased the looseness of soil resulting in increased soil volume and this way increasing macropores and porosity percentage of soil. Due to the influence of soil fauna whose burrowing and feeding activity form new pores.

_3. **Soil Structure**: - Organic matter causes soil particles to bind and form stable soil aggregates, which improves soil structure. Mostly clay humus complex are formed and these will further form porous granular structure of soil also known as crumby structure. This crumby structure is best for agriculture.

4. **Water holding Capacity**: - The addition of organic matter to the soil usually increases the water holding capacity of the soil. With better soil structure, permeability (infiltration of water through the soil) improves, in turn improving the soil's ability to take up and hold water. This is because the addition of organic matter increases the number of micropores and macropores in the soil either by "gluing" soil particles together or by creating favourable living conditions for soil organisms.

5**. Soil Texture**: -Organic manures improve the soil texture both heavy and light soils. They provide food substances to microorganisms and enhance their activity thereby increasing

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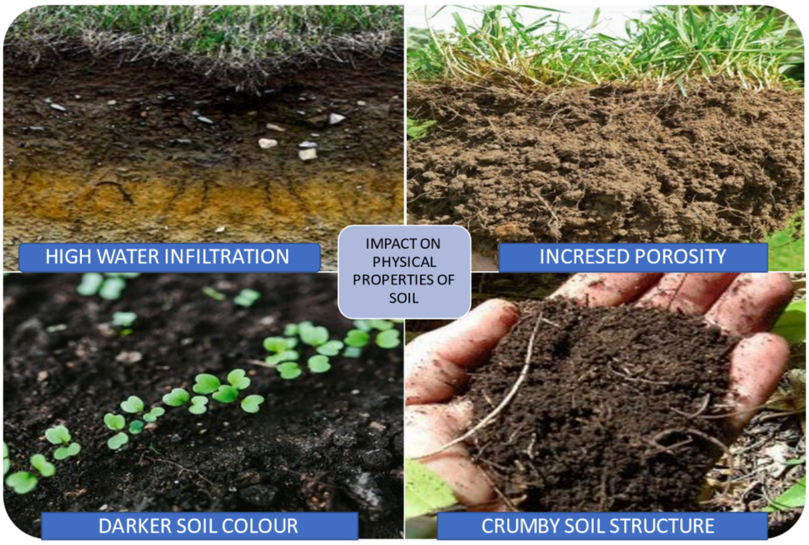
macro pore space in soil; this will improve drainage in heavy soil. Whereas in light soil organic manures increase water holding capacity by increasing micro pore space.

6. **Soil Thermal Properties**: - Soil thermal properties are considered a function of soil organic matter and soil carbon pool. Soil organic matter alters the thermal properties of soil because of its black dark nature. The albedo of soil gets reduced by the potential increase of dark colour and more heat gets absorbed. The soils with good amount of organic matter have ample germination and higher crop growth because of the favourable temperature.

7**. Soil Infiltration and Percolation**: - The important characteristic of soil affecting the soil infiltration is porosity of soil. The organic matter has a direct impact on the soil porosity and as the soil organic matter increases the porosity of the soil is also enhanced.

Percolation or downward movement of water is reliable on uninterrupted pore space in soil. Again organic manures increase the total pore space specially macro pore space this way enhance percolation rate in soil.

8. **Soil Colour**: - . The application of soil organic matter darkens the soil. The dark colour soil having high amount of the organic matter applied by various organic farming systems holds a largeamount.



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On Soil Chemical properties

1. Cation exchange Capacity: - Organic manures have very high CEC. In addition to this organic manures have porous structure this way increase the effective surface area and improve CEC of soil.

2. pH :- organic manures application decreases the pH of soil because by the decomposition of organic matter, microorganisms produce organic acids and decreases soil pH.

3. Nutrient status of Soil: - organic manure significantly improves the soil's capacity to store and supply essential nutrients such as nitrogen, phosphorus, potassium, calcium and magnesium etc. because organic matter improves the CEC of soil. Micro nutrients are become more available to plants due to chelating action of organic manures.

4. Buffering Capacity: - The buffering capacity of soil is the resistance to change in pH when an acid or base is added. At the pH value between 5 and 7.5, soil organic matter and clay acts as a sink for H and OH and the buffering capacity is governed by exchangeable reaction. soil organic carbon was reported 300 times in comparison to kaolinite. The presence of various functional groups (amine carboxylic, alcohol, phenolic, and amide) in soil organic matter allows it to act as a buffer over a wide range of soil pH.

5. Adsorption and Complexation: - . The complexation of soil organic matter with inorganic material enhances the soil fertility as it increases the availability of soil phosphorus by blocking iron, aluminium, and calcium adsorption sites. The presence of functional groups (COOR, NH_2, OH, NHR, $CONH_2$) are very important for adsorption of ions on humus particles. Organic manures increase the absorption of heavy metals (Cadmium, arsenic, and led) by forming insoluble complexes. These insoluble complexes decrease the soil pollution and make them contamination free.

On Soil Biological properties

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1. Microbial Biomass: - organic matter provides food, nutrients and habitat for microorganisms. In the presence of adequate organic matter microorganisms grows well and flourish.

2. Soil Enzymes: - These microorganisms produce specific exudates or secretions rich in enzymes as well as nutritive vitamins and minerals. These secretions play an important role in nutrient cycling and making them more readily available to plants.

3. Soil Biodiversity: -The soil biodiversity is indicator of soil health, as greater biodiversity means greater soil stability in terms of certain functions, such as maintenance of soil structure, assimilation of organic wastes, and nutrient cycling.

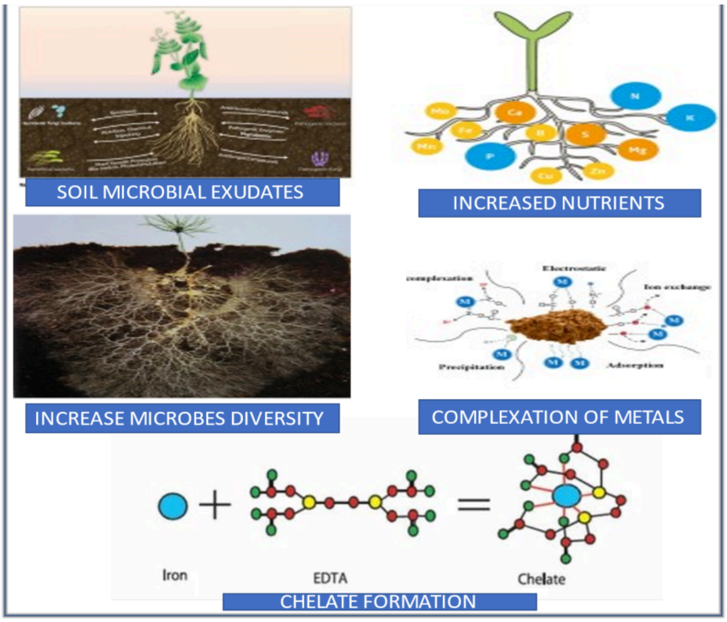

FIG: EFFECT ON SOIL CHEMICAL AND BIOLOGICAL PROPERTIES

CONCLUSION:-

Unjudious and unscientific use of inorganic fertilizers and wastage of all farm available organic sources leads to degradation of soil (low organic carbon, nutrient deficiency). Due to NBS farmers are incorporating higher doses to field, this creates a uneven distribution and shortage of fertilizers as well. For overcoming this land degradation as well as shortage of

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fertilizers at peak time, farmers have to integrate both inorganic as well as organic sources. These organic manures and bio fertilizers are not only supplying the nutrients to crop plants but also healing the degraded lands by improving their physical chemical and biological properties.Now trend is moving towards organic farming. Organic farming is labour intensive which creates more employment in rural areas. Moreover awareness of people for healthy and organic food increasing the demand, therefore in last decade organic farming area is increasing day by day.

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Effect of foliar application of Urea and Nano urea levels on quality, physiological and leaf nutrient content attributes of Acid lime (Citrus aurantifolia Swingle) cv. Kagzi.

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Abstract

The study's outcomes shed light on the effects of different Urea and Nano urea applications on various attributes of acid lime cv. Kagzi fruits. Notably, when Urea was applied at a 2.0% rate, it brought about substantial improvements in several key parameters. Firstly, fruit characteristics displayed noteworthy changes, with the fruit weight increasing to 67.90 gm, fruit length measuring 57.92 mm, and fruit breadth reaching 47.96 cm. Secondly, Juice properties saw positive developments, as the juice content rose to 51.19%, and the TSS level reached 10.46°brix, resulting in a higher TSS/Acid ratio of 1.65. Thirdly, nutritional content was enhanced, evident in the elevated levels of ascorbic acid (60.89 mg/100 ml) and a juice pH of 2.40. Additionally, the chlorophyll content also experienced an increase, with chlorophyll a at 1.217 mg/g, chlorophyll b at 0.717 mg/g, and a total chlorophyll content of 1.933 mg/g. Moreover, the relative water content in acid lime leaves was found to be 75.86% It is worth mentioning that the Ta treatment, which included Urea at 2.0%, exhibited minimized acidity levels at 6.47%. In terms of leaf nutrient content, the 2.0% Urea application (T, treatment) resulted in the highest leaf nitrogen content (2.05%) and leaf phosphorous content (0.16%). These findings underscore the significant impact of Urea on the quality, nutritional content, and growth attributes of acid lime cv. Kagzi, with the 2.0% Urea treatment proving most favourable for most measured parameters.

Key words: Citrus, Acid Lime, Kagzi, Quality, Urea, Nano urea, Leaf N, P, K

Introduction

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Acid lime, scientifically referred to as Citrus aurantifolia Swingle, is an evergreen fruit tree belonging to the Rutaceae family. It is characterized by its small size and bears fruits known as acid limes. This fruit is well known for its distinctive tangy flavour and is highly valued for its versatile applications in both culinary and medicinal uses. The acid lime tree is native to Southeast Asia, particularly India, and is commonly cultivated in tropical and subtropical regions around the world Globally, India holds first rank in production of acid lime (Citrus aurantifolia Swingle) with production 35.86 lakh metric tons and an area 3.06 lakh hectares as per third advance estimate of Ministry of Agriculture and farmers Welfare data of the year 2021-22 (Anon., 2021-22). Acid lime is gaining popularity among citrus growers due to its versatility in adapting to diverse agro-climatic and soil conditions, cost effective cultivation, year round fruit bearing capability, improved fruit storage properties, and steady demand in the domestic market (Ladaniya *et al* 2020) The increasing interest in foliar fertilizers is driven by the numerous advantages of foliar application methods. These include the rapid and efficient response to plant needs, reduced product quantities required and the independence from soil conditions. The application of supplementary foliar fertilization during crop growth has been acknowledged for its ability to enhance the mineral status of plants and ultimately boost crop yield (Kolota and Osinska 2001) Most plants absorb foliar applied urea rapidly and hydrolyse the urea in the cytosol (Witte *et al.* 2002). Urea and Nano urea can be applied to plants through the foliage, enabling efficient nitrogen management that reduces nitrogen losses to the environment. (Yildrim *et al.* 2007). Acid lime is cultivated in tropical and subtropical regions of India Acid lime (*Citrus aurantifolia* Swingle) is prized for its tangy flavour in culinary delights and beverages, while also providing essential nutrients and antioxidants for health benefits. Its versatility extends to medicinal properties, and its cultivation contributes significantly to agriculture and culinary industries. Acid lime crop is economically important for farmers as it provides year round harvest, ensuring a steady return With the growing concern for sustainable agriculture and environmental protection, there was a need felt to explore alternate nutrient management practice Traditional urea application may lead to nutrient losses through leaching and volatilization. Evaluating the efficacy of Nano urea in comparison can provide insight into its potential to enhance nutrient use efficiency, thereby conserving nutrient resources. By comparing the effect of Urea and Nano urea on acid lime, which foliar treatment results in better productivity and improved fruit quality.

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Keeping all these facts in mind, the present investigations were conducted to provide valuable information to farmers and the agriculture industry to optimize their nutrient management practices

Materials and Methods

The investigation titled "Comparative assessment of Urea and Nano urea foliar applications on quality, physiological and leaf nutrient content attributes of Acid lime (*Citrus aurantifolia* Swingle) cv. Kagzi, was carried out from June to December 2022 at the well-established Kagzi lime orchard of College of Horticulture and Forestry, Jhalawar, a constituent College of Agriculture University, Kota. The study involved 14-year-old acid lime plants, totalling fifty-four in number, spaced at regular intervals of 6 m x 6 m. The experiment included nine treatments, incorporating different concentrations of Urea (0.5%, 1.0%, 1.5%, and 2.0%) and Nano Urea (500 ppm, 1000 ppm, 1500 ppm, and 2000 ppm). Two rounds of foliar spraying were administered for each treatment, commencing on 7th July 2022, followed by the second spray 30 days later. The soil composition predominantly had a clay loam texture with traces of heavy clay. The primary objective of this study was to assess the influence of Urea and Nano Urea foliar applications on the quality attributes of Kagzi Acid Lime, yielding significant insights for the improvement of agricultural practices

1. "Quality parameters were recorded light of December 2022" fortnight at horticultural maturity of fruits during second

2. "Leaf nutrient analysis and physiological parameters were initially measuredand then again at the completion of the experiment as per standard analytical procedures".

Treatment Details

The area of the experimental block was 2160 m^2 accommodating 54 acid lime cv Kagzi plants. Treatment comprises two factors, first four levels of Urea and second, four levels of Nano Urea and control. Thus a total of nine treatments having a unit replication of two plants with a total of 54 plants were tested applying these treatments. The details of treatments evaluated under study are given in table 2.

Table 2 : Details of various treatments including Urea and Nano Urea

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T_0 (water spray),

T_1 (Urea @ 0.5%).

T_2 (Urea @ 1.0%),

T_3 (Urea @ 1.5%).

T_4 (Urea 2%),

T_5 (Nano urea @ 500 ppm).

T_6 (Nano urea @1000 ppm),

T_7 (Nano urea @ 1500ppm)

T_8 (Nano urea 2000ppm) as applied foliar treatments

Leaf chlorophyll content was quantified following the method suggested by Sadasivam and Manickam (1997). Leaf N content was determined using alkaline potassium permanganate method (Thakur *et al.* 2012). The leaf P and K content in leaf samples was assessed using the methodology outlined by Thakur *et al.* (2012).

The data collected during the experiment was subjected to statistical analysis using Analysis of variance (ANOVA) technique. The significance of the treatment was tested through F-test at a 5% level of significance. To evaluate the significance of the differences, the critical difference (CD) was calculated among the different treatments.

Result and Discussion

Below are the comprehensive results of the experiment, supported by relevant tables:

Fruit Weight: Significant variations were observed in the fruit weight of Kagzi lime in response to various Urea and Nano urea treatments. Table 1.0 presents the results, revealing that the maximum fruit weight (67.90 g) was recorded in cv. Kagzi lime with the T, treatment (Urea @2%), while the minimum fruit weight (40.89 g) was recorded in the To treatment Although there was an increase in fruit weight of acid lime with Nano urea, the Ts treatment

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with Nano urea application @ 2000 ppm showed a value of 52.68 g. Despite this, the overall highest fruit weight was recorded with the T_4 treatment.

Fruit length (mm): Various urea and Nano urea treatments led to significant variations in the fruit length of acid lime. The findings presented in table 1 demonstrate that the highest fruit length (52.72 mm) in acid lime cv. Kagzi was observed in the T. treatment (Urea @ 2%). while the lowest fruit length (41.76 mm) was recorded in the To treatment. Similarly, the application of different levels of Nano urea also increased the fruit length in acid lime cv. Kagzi, with the maximum fruit length (45.70 mm) recorded in the Ts treatment using Nano urea @ 2000 ppm. The overall results indicate that the fruit length was highest in the T_4treatment (Urea (@ 2%) compared to the Nano urea treatments.

Fruit breadth (mm): The findings presented in table 1 indicate that the highest fruit breadth in acid lime cv. Kagzi (47.36 mm) was observed in the T_4 treatment (Urea (@) 2%), while the minimum length (40.87 mm) was recorded in the T_0 (Control) treatment. The application of different levels of Nano urea resulted in an increase in fruit length, with the maximum value (46.35 mm) measured in the T'_8 treatment (Nano urea@ 2000ppm) However, the overall maximum enhancement in fruit length (47.36 mm) was recorded in the T_4 treatment (Urea @ 2%) when compared to the Nano urea treatments.

Juice (%): The results presented in table 1 demonstrate that the maximum juice recovery in Kagzi lime (51.19%) was achieved in response to the T_4 treatment (Urea @ 2%), while the minimum (38.34%) was observed in the T_0 (Control) treatment. Additionally, the application of Nano urea treatments resulted in an increase in juice recovery percentage, and the highest Juice recovery (49.21%) was obtained through the T_8 treatment (Nano urea @ 2000 ppm). Overall, upon comparative evaluation of Urea and Nano urea treatments, it was found that the highest juice recovery (51 19%) was estimated in the T_4 treatment, which included Urea @ 2.0%

TSS (brix): The data presented in table 1 illustrates the variations in the total soluble solids (TSS) content of acid lime cv. Kagzi under different Urea and Nano urea treatments. The highest TSS value (10.46 brix) was recorded in the T_4 treatment, where Urea was applied at a rate of 2% The application of Nano urea at different doses resulted in inconsistent variations

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in TSS levels, with the highest values (10.28°brix) observed in both the T_5treatment (Nano urea 500 ppm) and the T_7 treatment (Nano urea (@ 1500 ppm), which were higher than the control group (9.30°brix). However, upon overall evaluation, the maximum TSS content (10.46 brix) was measured in the T_4 treatment with Urea at 2.0%

Acidity (%): Upon examining the data presented in table l, it becomes evident that the acidity of the lime juice samples displayed significant variations in response to the different foliar treatments. The lowest acidity of 6.47% was recorded in the T_4 treatment (Urea (@) 2%), and this value was notably lower compared to the other treatments. In contrast, the highest acidity content of 7.25% was observed in the T_0 treatment, which served as the control. Moreover, the various doses of Nano urea treatments revealed a reduction in acidity content across all the Nano urea treatments. The minimum acidity content (6.53%) was estimated in the T_8 treatment, where Nano urea was applied at a rate of 2000 ppm during the horticultural maturity of acid lime fruits.

TSS/Acidity ratio: The TSS/Acidity ratio is a crucial parameter used to assess fruit quality in acid lime and other citrus fruits, indicating the balance between sweetness and acidity, which are essential aspects of fruit taste. The T_4. treatment, with Urea applied at 2%, resulted in the highest TSS/Acidity ratio (1.65), indicating a better balance between sweetness and acidity in the fruit and favourable fruit quality. In contrast, the T_o treatment (Control) exhibited the lowest TSS/Acidity ratio (1.27), suggesting an imbalanced combination of sweetness and acidity in the fruit. Nano urea treatments showed varying trends in the TSS/Acidity ratio at different doses, implying inconsistent effects on fruit quality. Among the Nano urea treatments, the T_8 treatment with Nano urea applied at 2000 ppm recorded the highest TSS/Acidity ratio (1.56), indicating a relatively better balance of sweetness and acidity compared to other Nano urea treatments. Overall, the comparative evaluation of urea and Nano urea treatments revealed that the best TSS/Acidity ratio (1.65) was obtained in the T_4 treatment, where Urea was applied at 2.0%. This suggests that the Urea treatment at this concentration was more effective in achieving the desired fruit quality with the right balance of sweetness and acidity.

Ascorbic acid (mg/100 ml of juice): The level of ascorbic acid in acid lime fruits displayed significant variation when exposed to different treatments involving Urea and Nano urea.

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Among these treatments, the highest concentration of ascorbic acid, measuring 61.89 mg/100ml, was observed in T_4 treatment, which involved the application of Urea at a concentration of 2%. On the other hand, the control group (T_0 treatment) exhibited the lowest ascorbic acid content, measuring 44.56 mg/100ml. The ascorbic acid content increased with varying doses of Nano urea, and the maximum ascorbic acid content (57.75 mg/100ml) was achieved in T_8treatment (Nano urea (@ 2000ppm). However, the overall comparative assessment revealed that the highest ascorbic acid content (61.89 mg/100ml) was recorded in T_4 treatment, where Urea was applied at a concentration of 2.0%

Juice pH: The current research on foliar applications of Urea and Nano urea treatments in acid lime cv. Kagzi fruits revealed variations in juice pH The highest juice pH value (2.40) was observed in T_4. treatment, which showed similar performance to T_3 and T_2 treatments with pH values of 2.38 and 2.35, respectively. On the other hand, the lowest juice pH (2.22) was recorded in the control group, T_0. Moreover, the application of Nano urea treatments at different levels resulted in lower juice pH values (ranging from 2.22 to 2.28) compared to various Urea levels.

Physiological Attributes

Chlorophyll content (mg g')

The application of foliar treatments comprising Urea and Nano urea on acid lime cv. Kagzi led to a noticeable increase in total chlorophyll content across various treatments. The changes in chlorophyll accumulation of Kagzi lime leaves in response to foliar application of Urea and Nano Urea treatments are depicted in Fig. 1 The T_4 treatment, which involved Urea at a 2% concentration, exhibited the highest chlorophyll a, chlorophyll b, and total chlorophyll content with values of 1.217 mg g^3. 8. 0717 mg g^1, and 1933 mg g, respectively. Conversely, the lowest accumulation of chlorophyll a (1.140 mg g^1), chlorophyll b (0.463 mg g and total chlorophyll (1.603 mg g^1) was observed in the T_0 (control) treatment, which did not receive any foliar treatment.

Relative water content (%)

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The graphical representation of data in fig 2 illustrates the changes in RWC (Relative water content) of acid lime cv. Kagzi leaves. The overall maximum relative water content (75.86%) in Kagzi lime leaves was estimated in T_4 treatment (Urea @ 2.0%) during December 2022 and minimum relative water content (68.05%) was measured in T_0 (Control) treatment.

Leaf nutrient analysis

Effect of N (%) of acid lime cv. Kagzi leaves

The experiment conducted on acid lime cv. Kagzi trees involved the application of different treatments, including Urea and Nano urea, through foliar application. The researchers measured the effect of these treatments on the final leaf nitrogen status of the acid lime trees after harvesting the fruits in December 2022.

The results, as depicted in Figure 4, showed that the treatment T_4, which involved the application of Urea at a concentration of 2%, resulted in the highest leaf nitrogen content, with a value of 2.05%. Following closely behind was the T_3, treatment, which used Urea at a concentration of 1.5%, and it exhibited a leaf nitrogen status of 2.01%. The third most effective treatment was T_8, which utilized Nano urea at a concentration of 2000 ppm, and it yielded a leaf nitrogen content of 2.01%.

From these findings, it can be inferred that the application of Urea, particularly at a higher concentration of 2%, had a more significant impact on increasing the leaf nitrogen status of the acid lime cv. Kagzi trees compared to the application of Nano urea at the given concentration. This suggests that Urea, when applied via foliar application, might be a more efficient nitrogen source for enhancing the nitrogen content in the leaves of the acid lime trees.

Effect on P (%) of acid lime cv. Kagzi leaves

The paragraph discusses the effects of foliar application of Urea and Nano urea treatments on acid lime cv. Kagzi trees, specifically focusing on their impact on leaf phosphorous (P) content. According to the results presented in Figure 5, it was observed that both Urea and Nano urea treatments led to an increase in leaf phosphorous content in the acid lime cv. Kagzi trees. The highest leaf phosphorous content (0.153%) was recorded in the T_4, treatment group, which involved the application of Urea at a concentration of 2.0% Interestingly, the T_8 treatment group, using Nano urea at a concentration of 2000 ppm, showed an equivalent leaf phosphorous content of 0.153% to that of the T_4 treatment

The data displayed in Figure 5 provides evidence that both Urea and Nano urea treatments are effective in augmenting the leaf phosphorous content in the acid lime cv. Kagzi trees. It suggests that the foliar application of these treatments can be beneficial in enhancing the phosphorous uptake and assimilation in the leaves, which can potentially contribute to improved plant growth, health, and fruit production.

Effect on K (%) of acid lime cv. Kagzi leaves

The results presented in Figure 6 indicate that the application of foliar spray treatments containing both Urea and Nano urea on Kagzi lime trees led to a consistent decrease in leaf potassium content across all the treatments. This reduction in leaf potassium content was observed when comparing the values after the application of the treatments to the initial values before the treatments were administered. The significant reduction in leaf potassium content in both the Urea and Nano urea treatments implies that these foliar spray treatments had an impact on the uptake, translocation, or utilization of potassium within the Kagzi lime trees. The decrease in leaf potassium levels suggests that either the applied nutrients (Urea and Nano urea) directly influenced the potassium levels or induced physiological responses in the trees that affected potassium uptake and distribution. The finding of a consistent decrease in leaf potassium content across all treatments suggests that both Urea and Nano urea treatments might have similar effects on the potassium status of the Kagzi lime trees.

Effect of Urea and Nano urea treatments on physico-chemical characteristics of acid lime cv. Kagzi fruits

The increase in fruit weight observed with the T_4 treatment (Urea @ 2%) can be attributed to the enhanced nitrogen availability provided by urea, which is a vital nutrient required for protein, enzyme, and chlorophyll synthesis involved in various biochemical processes within the plant. The foliar application of urea through the T_4. treatment likely stimulated the photosynthetic rate, leading to higher carbohydrate production and ultimately resulting in increased fruit weight. The role of nitrogen in enhancing cell wall strength and flexibility might have influenced fruit shape and breadth. Additionally, nitrogen closely associates with the absorption and assimilation of other essential nutrients like potassium (K) and calcium (Ca), crucial for cell expansion and fruit development. The increase in fruit length can be attributed to enhanced water uptake and turgor pressure within the fruit, facilitating the expansion and elongation of fruit tissues. the results of this study are in agreement with previous findings reported by various researchers in different fruit crops. Debajeet al. (2011) observed similar trends in acid lime, while Jat and Laxmidas (2014) reported comparable results in guava. Likewise, Prasad *et al.* (2015) and Al-Obeedet al. (2017) found analogous outcomes in Kinnow mandarin. These findings are further supported by Rathore and Chandra (2003), Prasad et al. (2015), and Sawale *et al*. (2021) in Sai Sharbati. Moreover, El-Tanany *et al.* (2009), Debaje et al. (2011), Prasad *et al.* (2015), Al-Obeeder *et al*. (2017), and Yadav *et al.* (2020) also reported consistent results in their studies on acid lime and Kinnow mandarin. The convergence of these outcomes strengthens the validity of the current study's findings and reinforces the understanding of the impact of the treatments on fruit growth and development. The higher juice recovery obtained in the T_4 treatment can be attributed to several factors. Firstly, the application of T_4. might have stimulated increased carbohydrate production, leading to an enhancement in cell number and size in various fruit tissues. Including the juice sac in acid lime. Additionally, urea, present in the T_4. treatment, plays a role as a source of nitrogen. It increases the osmotic pressure within the fruit cells, causing water to move from the surrounding tissue into the fruit cells, thereby increasing the juice percentage. The present findings are consistent with the results reported by Lakshmipathi *et al.* (2015), Prasad *et al* (2015), Rokaya *et al*. (2019) in Kinnow mandarin. Yadav *et al* (2020) in acid lime, and Senjam and Singh (2021) in Assam lemon. The convergence of these results reinforces the understanding of the impact of the T_4. treatment on juice recovery and supports the effectiveness of urea as a nutrient in enhancing juice yield in acid lime The increase in TSS observed under various treatments can be attributed to the influence of Urea and Nano urea on metabolic pathways, resulting in the accumulation of sugar in the fruit juice and an increase in enzymatic activity, contributing to higher TSS levels. These findings align with

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the results reported by Prasad et al (2015), Chouhan et al (2018) in acid lime, Yadav *etal* (2020) in acid lime, and Senjam and Singh (2021) in Assam lemon. Acidity in acid lime fruits is influenced by various physiological factors, including organic acid synthesis, respiration rates, sugar content, and nitrogen availability, which can potentially affect acidity levels. This is supported by the research conducted by Chouhan *et al*. (2018) and Yadav *et al*. (2020) in acid lime, Abdallah (2020) in Minneola Tangelo, and Senjam and Singh (2021) in Assam lemon, which corroborate the present findings and further emphasize the factors influencing TSS and acidity in acid lime fruits. The high TSS: acid ratio recorded in the T_4 treatment can be attributed to enhanced sugar accumulation in the acid lime fruits. With an increased supply of nitrogen, the acid lime plant might produce and accumulate more sugars, leading to higher TSS levels in the fruit juice. These findings are in line with the results reported by Saleem et al. (2008) in sweet orange. The research also indicates that the availability of nitrogen contributes to a rise in N_2 content within the acid lime cv. Kagzi fruits. This increase can be attributed to higher availability of ammonia, which enhances the presence of glutathione. Glutathione indirectly leads to an increase in the levels of ascorbic acid and has the ability to regenerate ascorbic acid from its oxidized form (dehydroascorbic acid), thereby maintaining an active pool of ascorbic acid within the fruit tissue. These results are further supported by previous research by Carpenter *et al*. (2018), Chouhan *et al*. (2018) conducted on acid lime under Malwa plateau region, as well as the findings of Rokaya *et al.* (2019). The consistency of these supporting studies strengthens the validity and relevance of the present investigations. The higher juice pH could be attributed to the fact that urea application might influence the uptake and utilization of other essential nutrients such as potassium (K) and calcium (Ca) which play a role in maintaining the pH balance in plant cells. The results of present findings are in accordance with those reported by Lasa *et al*. (2012).

Effect of Urea and Nano urea treatments on physiological variables of acid lime cv. Kagzi fruits

The significant increase in chlorophyll a, chlorophyll b, and total chlorophyll

content in the T_4 treatment can be attributed to the positive response of acid lime plants to the foliar application of Urea at a concentration of 2.0%. This response likely led to enhanced chlorophyll synthesis and improved photosynthetic efficiency in the plants. Additionally, the

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increased activities of Rubisco (Ribulose-1,5-biphosphate carboxylase/oxygenase), a keyenzyme involved in carbon fixation during photosynthesis, may have contributed to the heightened chlorophyll content. These findings align with the work of Dhaliwal and Rohela (2016) in rough lemon and Abdallah (2020) in their studies, further validating the positive impacts of foliar Urea treatments on chlorophyll content in citrus plants. The present results highlight the potential of Urea foliar application as an effective method to enhance photosynthetic activity and overall health in acid lime cv. Kagzi.

The relatively better Relative Water Content (RWC) measured in the T_4 treatment could be attributed to multiple factors. Firstly, there might be an increase in osmotic adjustment, leading to a higher osmotic potential in the leaf cells. This allows the cells to retain more water and maintain higher RWC (%) Secondly, Urea might influence stomatal behaviour, leading to better stomatal regulation and improved water retention in the leaves. Additionally, nitrogen stimulates cell expansion, allowing the leaf cells to accommodate more water and maintain higher RWC (%) These results are consistent with the findings reported by Mohammadi and Khejri (2018) in date palm, providing further support for the positive impact of Urea treatment on the relative water content in acid lime plants.

Effect of Urea and Nano urea treatments on leaf N, P and K content of acid lime cv. Kagzi

The increase in leaf nitrogen content of acid lime cv. Kagzi can be attributed to several factors. Firstly, the rapid uptake of nitrogen from the applied foliar Urea and Nano urea treatments contributed to higher nitrogen levels in the leaves. Secondly, the improved mobility of nutrients in the plants facilitated the efficient movement of nitrogen within the leaf tissues. Thirdly, enhanced urea hydrolysis and nitrogen release further enriched the nitrogen content in the leaves. Lastly, better nitrogen assimilation processes in the plants led to the synthesis of nitrogen-rich organic compounds. These findings are in line with previous studies by Bondada et al. (2001), El-Otmani et al. (2004) in clementine mandarin, Abdallah (2020), and Deparpanah (2017) in pomegranate, which support the positive impact of foliar Urea and Nano urea treatments on leaf nitrogen content in citrus plants

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The increase in leaf phosphorus (P) content of acid lime cv. Kagzi can be attributed to indirect biochemical and physiological processes in the plants. The application of foliar Urea and Nano urea likely stimulated root growth and activity due to increased nitrogen availability. Healthy and active roots play a crucial role in nutrient uptake, including phosphorus. Additionally, the metabolism of urea in plants and the subsequent production of ammonia (NH_3) may raise the pH in the vicinity of the urea-treated leaves, creating a slightly alkaline environment. This alkaline environment stimulates the activity of certain phosphatase enzymes responsible for breaking down organic phosphorus in the soil, making inorganic phosphorus more available for uptake by the roots and subsequent transportation to the leaves. These results are consistent with the findings reported by Abdallah (2020). The reduction in leaf potassium (K) status of acid lime cv. Kagzi may be a result of nutrient allocation changes after fruit harvest. The trees may reallocate nutrients that were previously allocated to fruit development and growth towards other parts of the trees, including leaves. This redirection of nutrients leads to a decrease in overall nutrient content in the leaves, including potassium. Additionally, the increased nitrogen levels from the foliar Urea and Nano urea treatments may interfere with the uptake of potassium, contributing to the relative reduction in leaf potassium content. These findings are supported by the research conducted by Kumar et al. (1994) and Nava et al. (2010).

Conclusions

Based on the rigorous and comprehensive investigation conducted on the comparative foliar application of Urea and Nano urea in acid lime cv. Kagzi trees in Vertisols of Jhalawar district, the study leads to an emphatic conclusion. The T_4 treatment, which involved the application of Urea at a concentration of 2.0%, emerges as the superior choice for enhancing various aspects of the acid lime cv. Kagzi. Firstly, the T_4 treatment demonstrated remarkable advancements in quality attributes, with a particular emphasis on increasing the ascorbic acid content of the fruit. Ascorbic acid, or vitamin C, is a vital component that enhances the nutritional value of the acid lime, making it more appealing to consumers seeking healthier food choices

Secondly, the T_4 treatment exerted a profound and positive impact on the physiological aspects of the acid lime cv. Kagzi. The plants treated with Urea at a 2.0% concentration

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exhibited unparalleled growth, vigour, and overall health compared to the other treatments This indicates that the T_4 treatment significantly contributed to the overall well-being and vitality of the acid lime plants, potentially leading to improved resistance to environmental stresses and diseases

The evidence presented in the study strongly supports Urea foliar application at a 2.0% concentration as the definitive approach for optimizing the growth, quality, and agricultural potential of acid lime cv Kagzi in the Vertisols of Jhalawar district. By reaffirming the significance of this treatment, the research underscores its importance for sustainable and productive citrus cultivation in the region

In summary, the study's findings highlight the superiority of the T_4 treatment featuring Urea at a 2.0% concentration, which positively impacts the fruit's nutritional value and physiological characteristics. This conclusion has practical implications for citrus growers in Jhalawar district, providing them with valuable insights to maximize the productivity and quality of acid lime cv Kagzi cultivation, ultimately contributing to the region's agricultural success and economic growth

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Table 1.0: Physico-chemicalcharacteristics of acid lime cv. Kagzi fruits in response to foliar application of Urea and Nano urea treatments

Treatments	Fruit wt.(g.)	Fruit lenght(mm)	Fruit breadth (mm)	Juice (%)	TSS(^{0}brix)	Acidity (%)	TSS/ Acidity ratio	Ascorbic Acid (mg/100ml)	Juice pH
T_0	40.89	41.76	40.87	38.34	9.30	7.25	1.27	44.56	2.22
T_1	44.73	43.53	42.09	47.55	9.93	6.98	1.45	53.21	2.32
T_2	48.09	43.63	43.06	46.25	10.26	7.05	1.41	54.38	2.35
T_3	51.46	44.48	44.68	49.66	10.28	6.88	1.46	60.31	2.38
T_4	67.90	52.72	47.36	51.19	10.46	6.47	1.65	61.89	2.40
T_5	40.56	41.24	40.53	46.05	10.28	6.56	1.47	48.54	2.22
T_6	45.85	43.29	42.43	47.36	10.07	6.66	1.46	51.36	2.22
T_7	48.42	43.52	43.13	46.90	10.28	6.68	1.55	55.65	2.24
T_8	52.68	45.70	46.35	49.21	10.15	6.53	1.56	57.75	2.28
SEm(±)	1.41	0.97	0.78	0.68	0.15	0.05	0.02	0.45	0.02
CD 5%	4.25	2.92	2.36	2.06	0.47	0.17	0.06	1.35	0.06

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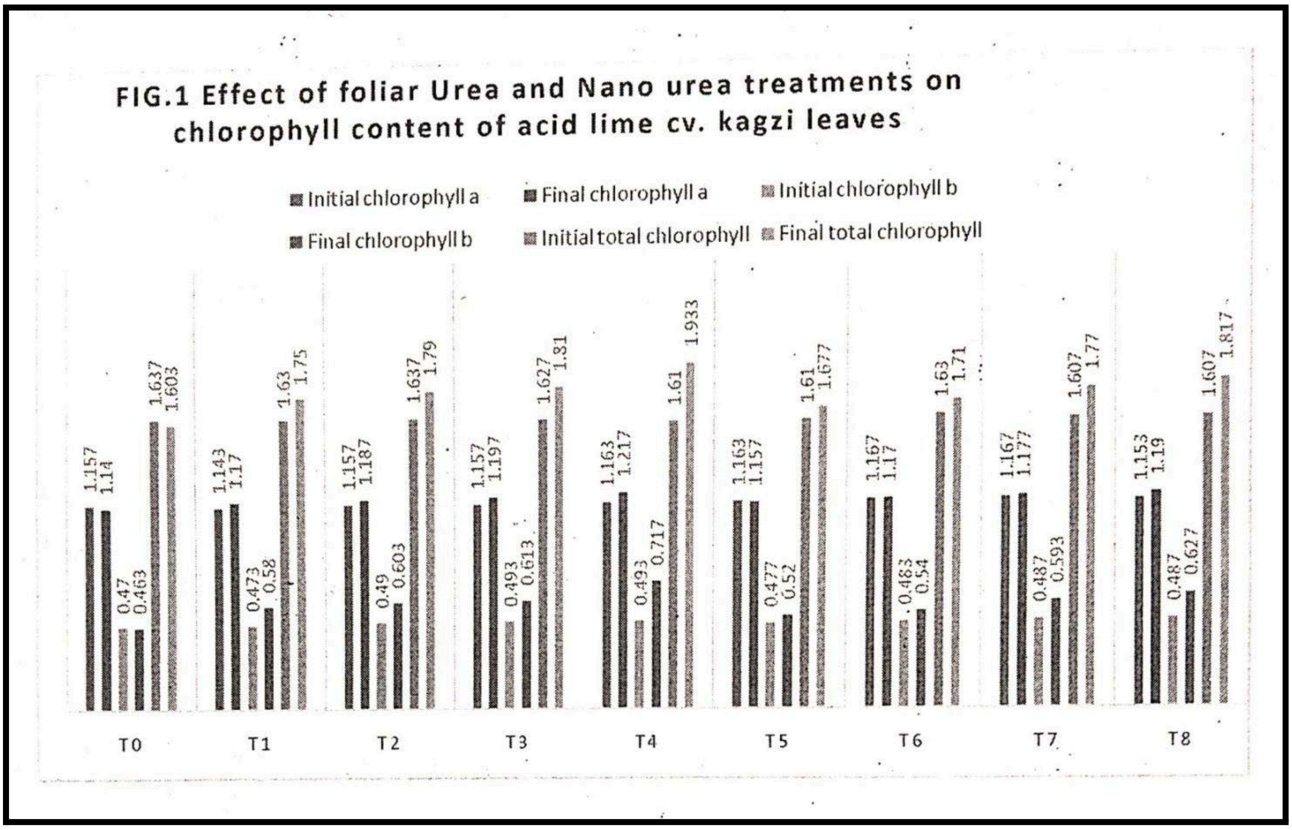

FIG.1 Effect of foliar Urea and Nano urea treatments on chlorophyll content of acid lime cv. kagzi leaves

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Fig.2 Effect of foliar Urea and Nano Urea treatments on Relative water content(%) of acid lime cv.Kagzi leaves

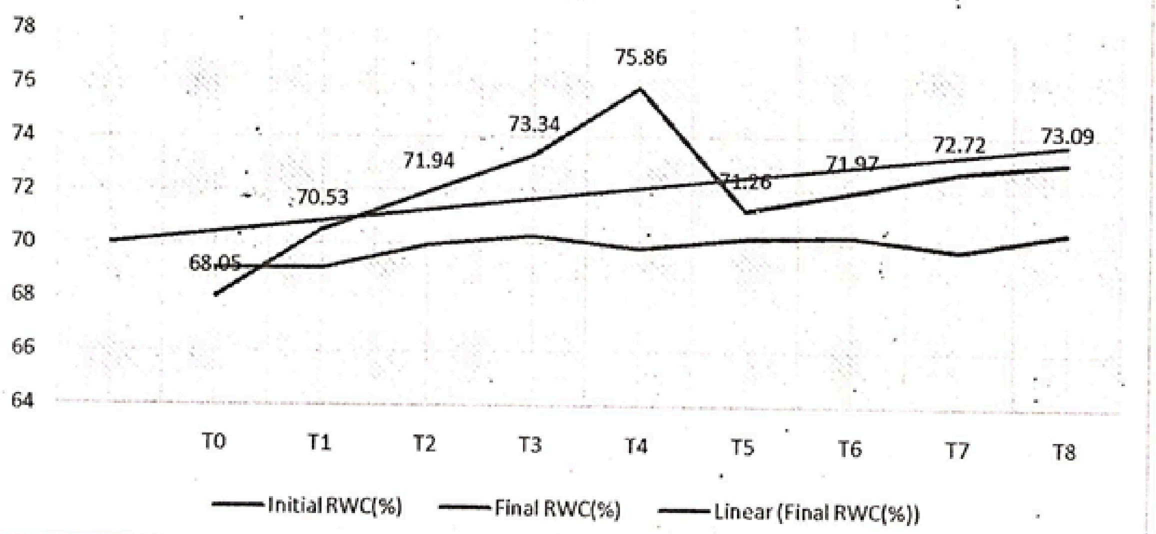

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Fig.4 Effect of Foliar urea and Nano urea on leaf nitrogen content of acid lime cv.Kagzi

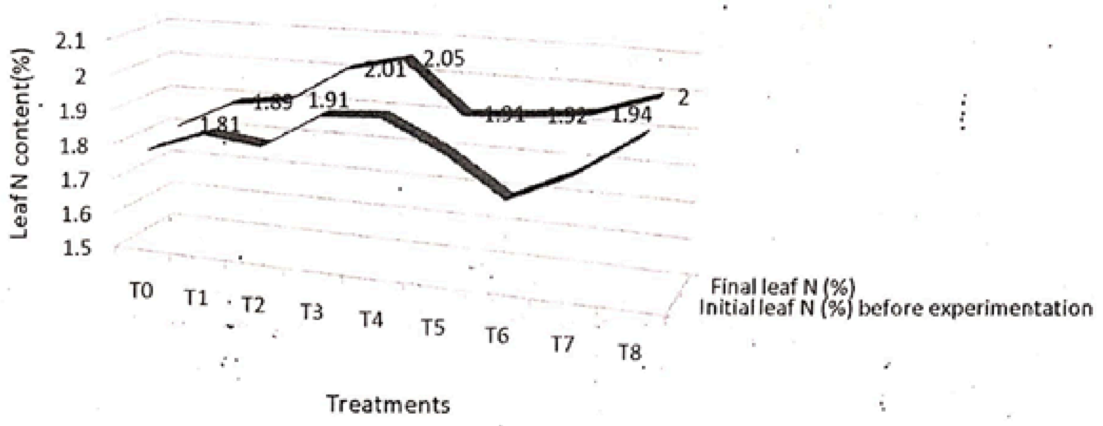
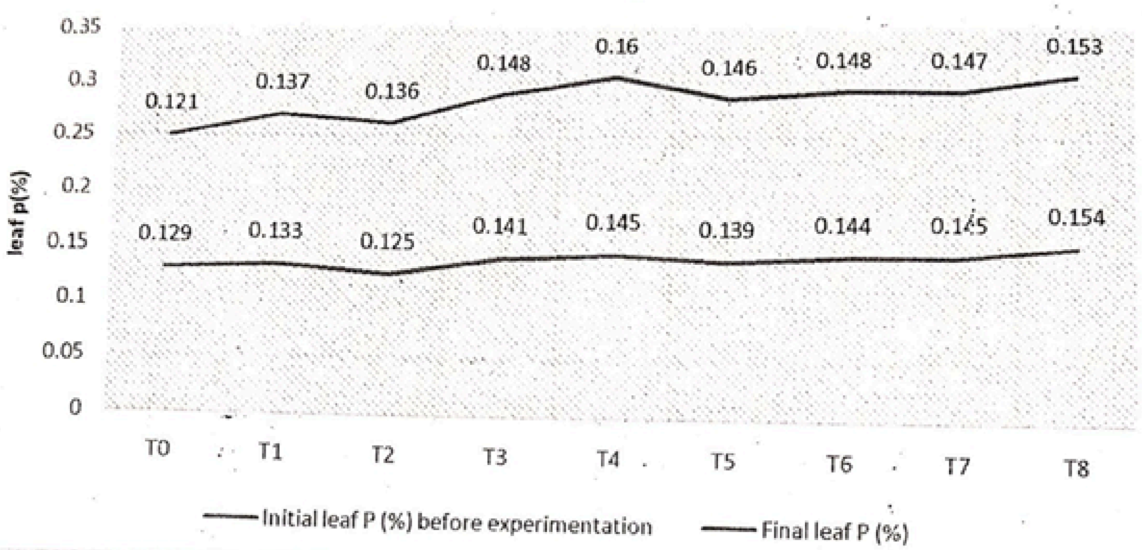


Fig.5 Effect of foliar urea and Nano Urea treatments on leaf phosphorous content of acid lime cv.kagzi



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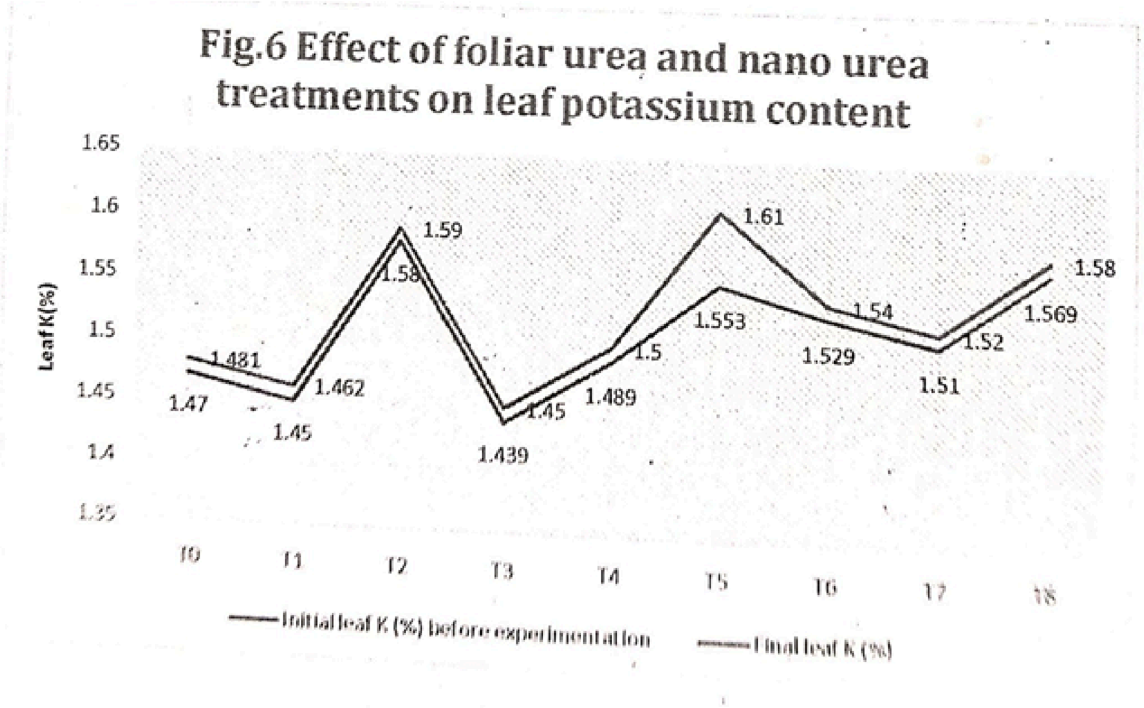

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Research Article

Organic Farming: A Socio-Ecological Approach to Long-Term Survival

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Abstract

The study delves into the dynamic interplay between social and ecological dimensions within the context of organic farming, aiming to elucidate its role in fostering long-term sustainability. The research explores the multifaceted benefits of organic farming practices, encompassing environmental conservation, human health, and community resilience. By adopting a socio-ecological lens, the paper analyzes the reciprocal relationships between organic farming methods and societal structures, emphasizing the potential of this approach to address contemporary challenges in agriculture and food systems. Furthermore, the study investigates the impact of organic farming on biodiversity, soil health, and carbon sequestration, underscoring its contribution to mitigating climate change The paper concludes by advocating for the widespread adoption of organic farming as a holistic and resilient strategy for ensuring the long-term survival of both ecosystems and human societies.

Key Words: Organic farming,

Introduction

Agriculture is the main source of income for half of Indian population. Farmers employ various agricultural strategies, based on the kind of soil, climate of the area, geographic location and irrigation facilities available, such as subsistence, shifting, plantation, intensive, dry and wet cultivation and terracing. Surprisingly, a diverse range of foods and agricultural products are cultivated employing various farming practices. In an era marked by rapid urbanization, industrialization and a growing disconnect from the organic world, the principles of organic farming offer a beacon of hope for humanity's long-term survival.

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Organic farming or regenerative agriculture is a holistic and sustainable approach that integrates traditional agricultural wisdom with modern ecological science. It goes beyond mere food production, emphasizing the harmonious coexistence of humans, flora and fauna This article explores the significance of organic farming as a socio-ecological approach to ensure our survival in the face of environmental challenges.

Agro ecological farming has recently gained popularity because it draws on traditional knowledge that is firmly embedded and connected with the land, its bio-resources, and climatic circumstances, while also reflecting socio-cultural demands. The concept of nutri-sensitive agricultural innovation, which is meant to use organic farm inputs, can be a financially feasible method for cultivating nutrient-rich crops for community consumption to promote good health and well-being. This farming system is the most successful paradigm for increasing farmer income, improving health, protecting the environment, using less water, lowering production costs, eliminating the need for synthetic chemical inputs and restoring soil health

Organic farming, according to the Hon'ble Prime Minister, will benefit 80% of the

agricultural population with modest land holdings of 2 hectares or less.Groundwater, on the other hand, is utilized to irrigate approximately 60% of arable land in our country, making it a significant resource in times of environmental disaster. Organic farming would thereby promote groundwater recharge for future generations. More than 1.5 lakh farmers currently operate on more than 20,000 acres of land distributed throughout the state's various agroclimatic zones and practices organic farming under the Central Government's Prakritik Kheti Khushal Kisan Yojana (PK3Y) Scheme.

Organic farming approach

Organic farming is not a recent innovation, it draws from indigenous agricultural practices that have been used for centuries in our country. The core principles of organic farming are as follows:

1. No-till Farming: Unlike conventional farming, which often involves tilling the soil, Organic farming promotes minimal soil disturbance. Tilling disrupts the soil's organic

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structure, leading to erosion, loss of fertility, and increased carbon emissions. No-till farming retains the soil's integrity, promoting better water retention and carbon sequestration.

2. Biodiversity: Organic farming encourages the cultivation of diverse crops, mirroring the organic ecosystems. This diversity reduces the losses as well as need of chemical pesticides and fertilizers and creates a more resilient and sustainable agricultural system.

3. Crop Rotation: Rotating crops helps prevent soil depletion and reduces the risk of pests and diseases. By mimicking organic patterns, organic farming optimizes soil health and productivity

4. Composting and Mulching: Instead of synthetic fertilizers, organic farming relies on composting and mulching to enrich the soil. These practices promote the growth of beneficial microorganisms and increase organic matter, enhancing soil fertility.

5. Use of Beneficial Insects: Organic farming encourages the presence of beneficial insects that organically control pests, reducing the need for chemical pesticides.

6. Minimal Use of Chemicals: Chemical inputs are minimized or eliminated. This reduces the environmental impact and produces healthier and more nutritious crops.

Organic farming, often known as traditional farming, doesn't use any pesticides. The agricultural system employs a diverse, agroecology-based approach that includes agri-horticultural crops, forest trees, animals, and functional biodiversity. Other names for it include Zero Budget Organic Farming (ZBNF), Subhash Palekar Organic Farming (SPNF), Chemical Free Agriculture, minimal input, and so on. This alternative farming methods emphasizes soil productivity in an organic manner aimed at promoting long-term soil, plant, and human health. It is a new dimension for sustainability and enhanced farmer revenue, and it is recognized as the foundation of crop diversity in mixed farming in terms of fruits, vegetables, spices, medicinal plants, and fragrant plants. ZBNF stands for zero cost or zero input organic farming and the amount gathered is considered net profit to the farmer. This zero-cost farming uses organic inputs to maintain ecological balance and promote soil health. This technique requires native-breed cattle, which are an important component of rural farming families. One cow is enough to start farming on 30 acres of land, according to this

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strategy. SPNF holds a lot of promise for low-income farmers. This strategy advocates for the full elimination of manmade chemical inputs such as fertilizers and pesticides. It encourages the employment of mulching technologies, symbiotic intercropping and organic combinations made from cow dung, urine, jaggery, pulse flour, and other organic materials.

The four basic components of organic farming to rehabilitate the soil are Jeevamrit, Beejamrit, mulching (acchadan), and Waaphasa. Organic plant protection products such as Agniastera, Brahmastera and Neemasters are created from cow dung, cow urine, and green chillies, among other, things. Jeevamrit's formulation boosts the organic microbial biota and earthworm activity in the soil. Soil, water, jaggery, pulse flour, cow dung, and urine are all used to make it. The second formulation, Beejamrit, combines cow dung and urine and treats seeds, seedlings, and other planting material. The third variants known as achchodana, which is a mulching method that uses three different types of mulch including straw mulch, soil mulch, and live mulch. It serves as a barrier to water evaporation and aids in the development of soil humus. The fourth and last one is waaphasa, which is a way of maintaining the soil's air and water molecules. It aids in lowering the additional watering consumption. Organic farming methods can help farmers to become less reliant on external inputs and enhance their social and economic well-being. It encourages the use of locally accessible resources and increases crop diversification, it can also boost food security

Economic implications

The adoption of organic farming practices can have potential economic benefits for farmers. The practice can be a viable approach to reduce input costs through the maximum practices utilized in he quality crop Brahmastra Subh One of Brahmastra M Shree better tFaUsermore, it's crop reduce their reliance on a single crop. This diversification strategy offers a buffer against crop failures, providing farmers with a more stable income.

Way forward

The way forward for promoting organic farming can be accomplished by supporting and promoting it through various schemes and initiatives. Financial incentives, training

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programs and research grants can encourage more farmers to adopt organic farming practices. The government should collaborate with agricultural universities and research institutions to improve innovative practices and crop combinations that suit local conditions. Steps should be taken to facilitate market linkages for farmers practicing organic farming which creates a demand for organic and eco-friendly products in the markets. Highlighting and sharing success stories can also inspire and motivate others to adopt similar practices. By implementing these strategies, Rajasthan and other regions can further promote organic farming as a viable and sustainable alternative to conventional farming

Challenges and Future Prospects

Despite its many benefits, Organic farming faces several challenges, such as the initial transition period from conventional farming and potential yield fluctuations. However, as awareness of the socio-ecological benefits of organic farming continues to grow, it is gaining momentum worldwide. Governments, NGOs, and agricultural organizations are increasingly supporting and investing in organic farming practices.

In conclusion, Organic farming is not merely a means of food production, it is a socio-ecological approach that recognizes the intricate interplay between humans and their environment. By prioritizing the health of the land, the well-being of communities, and the preservation of traditional knowledge, Organic farming offers a path toward long-term survival in a world facing pressing environmental challenges. Embracing organic farming practices is not just an agricultural choice but a commitment to our collective future, where humans and nature coexist in harmony.

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Research Article

Constraints Causing Concern to Animal Keepers Associated with " GOPAL YOJANA"

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Abstract

India holds 4th rank in the world with respect to livestock population. Whereas the animal milk production of the country is approximately 66.00 million tons. The target for the year 2000 AD is estimated to be the 70 million tons (Dairy India ,1997). The state of Rajasthan is known as the Denmark of India. The state possesses about 47.7 million live stock (Anon., 1992) and contribute with an annual milk production of 4.47 million tons. Thus, contributing approximately 9% to the country's total milk production. The development of farmers dealing with animal husbandry depends to a large extent on the improved wealth of animal husbandry. Animal husbandry is under going rapid scientific advancement during present days. A number of extension programs are introduced by the government to boost up milk production of our country. The most complex and significant problem of our age seems to be the blocks in effective dissemination of technology and its adoption at the individual animal- keepers level. Considering the severity of the problems, state of Rajasthan introduced an animal husbandry upliftment program in the name of the "GOPAL YOJANA" on Oct., 1990. The main objective of the yojana is to raise the economic status of the animal keepers by improving animal breeds. The yojana includes transfer of scientific and recent technical knowledge regarding nutritive fodder, utility of green fodder and improve breeds. Initially, the activities of the yojana were executed in 12 districts of south east Rajasthan. Almost a decade is over since this yojana was introduced in the state. In order to find out the problems perceived by the animal keepers in getting benefit of yojana a study was conducted. The study aimed at to identify the constraints as perceived by the beneficiary and non-beneficiary animal keepers in getting benefits of 'GOPAL YOJANA'.

Methodology

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The present study was undertaken in purposively selected Girwa panchayat samiti of Udaipur district, the selection of said panchayat samiti was done considering comparatively higher livestock population among all the other panchayat samiti. The Gopal Yojana under study was introduced in the said panchayat samiti well ahead during its introduction to Udaipur district of Rajasthan. Two Gopal one each the best performer and poor performer were selected based on their performance. A sample of 120 respondents, 60 each beneficiary (30 from each circle) and non-beneficiary of yojana were selected by the employing a simple random technique. Thus, the total sample of respondents consisted of 120 respondents from the study area.

Results and Discussions

To identify the constraints perceived by the animal keepers, a suitable schedule was developed for the study purpose. A perusal of data incorporated in Table -1 indicate that high prices charged by Gopal for A.I. was one of the severest constraints (MPS 67.50) perceived by the beneficiary of yojana. Likewise, less chances of success through A.I. done by the animal keepers. The other constraints viz., ignorance about cross breed cattle (MPS 50.80) failure in detecting the animal in heat (MPS 46.80) were also causing much concern to animal keepers who were availing benefits of Gopal yojana in the study area.

Table-1 Constraints perceived by animal keepers pertaining to breeding aspects of livestock management.

A. Breeding Aspect:

S.No.	Aspects	BN MPS	BN Rank	NBN MPS	NBN Rank
1	Ignorance about crossbreed cattle	50.80	3	87.50	7
2	Non availability of improved breeding bull in the village	36.60	6	90.00	6
3	Non availability of improved breeding bull in the village	38.30	5	100.00	4
4	Less chances of success through AI practices	53.30	2	109.10	3

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5	Charging of high prices for AI	67.50	1	150.01	1
6	Unhygienic instruments possessed by Gopal	33.30	7	120.80	2
7	Lack of skills in performing AI operations on the part of Gopal	30.00	8	92.50	5
8	Failure in detecting the animal in heat	46.80	4	86.60	8

BN- Beneficiary, NBN – Non beneficiary

On the other hand, high prices for AI were a major constraint causing concern to non-beneficiary animal keepers of the area with (MPS-150). Unhygienic instruments possessed by the Gopal was also considered as second priority constraints by the non-beneficiary respondents. This was followed by less chances of success through AI (MPS-109.1) and non-availability of improved breeding bull in the villages (MPS-100) with 111 and IV ranked constraints respectively in the rank order of constraints. The results are in line with the results of Sawant and Dhole (1997) who reported that inaccessibility of AI centers impracticability of taking cows to AI and high fee charged for AI were the major constraints faced by the respondents.

B. Feeding Aspect:

Table 2 Constraints perceived by the animal keepers pertaining to feeding aspect of livestock management:

S.No.	Aspect	BN MPS	BN Rank	NBN MPS	NBN Rank
1	Unavailability of mineral mixture	80.80	7	109.10	6
2	Ignorance of nutritive fodder crops	73.30	6	112.50	4
3	Lack of drinking water for animals	40.00	12	95.00	10
4	Lack of nutrition after calving	58.30	9	104.10	7
5	Unavailability of cost-effective green fodder in the area	79.16	3	121.60	1
6	Lack of land for fodder production	47.50	10	59.10	11

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7	Lack of irrigation water for fodder production during summer	46.60	11	120.80	2
8	Lack of timely and cheap concentration	80.00	2	100.80	8
9	Lack of technical guidance for green fodder	61.60	7	108.30	5
10	General shortage of feed and fodder	76.60	5	117.50	3
11	Expensive dry fodder in summer	77.60	5	100.00	9
12	Ignorance about nutritive fodder crops	59.16	8	100.00	8

BN- Beneficiary, NBN – Non beneficiary

The data presented in table 2 shows that un-availability of mineral mixture in the area was considered critical constraints by the beneficiary respondents of yojana. The beneficiaries have also reported that they are facing the problem of lack of timely and cheap concentrates (MPS 80) together with the unavailability of cost-effective green fodder (MPS 79.16) for feeding to their animals. This was followed by general shortage of feed and fodder (MPS 77.50) and expensive dry fodder in summer season (MPS 76.60) respectively. A close observation of data in table visuals a variation in according the ranks to various constraints pertaining feeding aspect by the beneficiary and non-beneficiary respondents. The findings are in agreement with the findings of Soni and Khaerde (1998) who reported that cost was the main reason for no providing balanced and commercial feds to animals. The results were further supported by Sharma (1981) who found that problem of cheap and timely availability of fodder was most important problem for tribals under MADA.

C. Heading and Weeding aspect:

Table-3 Constraints perceived by Animal Keepers pertaining to heading/weeding aspects of livestock management

S.No.	Aspect	BN MPS	BN Rank	NBN MPS	NBN Rank
1	Unhygienic conditions in village	47.50	3	83.50	5
2	Lack of regular vaccination facilities	38.30	4	100.00	4
3	Un awareness	35.00	5	106.6	3

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4	High charges for treatment of animals	76.60	1	119.10	1
5	High cost of medicines	53.30	2	116.60	2

BN- Beneficiary, NBN – Non beneficiary

The data in table 3 depicts the constraints faced by the animal keepers pertaining to heading/weeding aspect of livestock management. A high charge for treatment of animals (MPS 76.60) coupled high cost of medicines (MPS 53.30) were reported to be most important constraints causing concern to beneficiary animal keepers of Gopal yojana. Unhygienic conditions have also restricted them (MPS 47.50) to get more benefits from yojana. This was followed by lack of regular vaccination facility and general un awareness for animal care which were accorded IV and V ranks in the rank order. Non-beneficiary respondents were somewhat similar in according the ranks to the aspects under study through the ranks to the aspects under study through the MPS very greatly with that of MPS assigned by beneficiary respondents of yojana. Somewhat similar results were reported by Sath (1977) where he found that 67.00% of respondent did not have hygienic cattle sheds for rearing cattle.

D. Overall constraints perceived by Animal Keepers

S.No.	Major aspect	Bn MPS	Bn Rank	NBn MPS	NBn Rank	Z Value
1	Breeding	45.50	2	104.33	2	15.67**
2	Feeding	65.00	1	104.10	3	16.95**
3	Heading/Weeding	41.16	3	105.33	1	16.6**
	Overall	55.40		104.53		21.18**

** Significant at 1 per cent level

BN- Beneficiary, NBN – Non beneficiary

The data incorporated in table 4 shows that constraints pertaining to feeding aspect of livestock management were perceived at top priority and accorded 1st rank by the beneficiary respondents. This was followed by constraints pertaining to breeding (MPS 45.00) and heading/weeding (MPS 41.16) with IInd and IIIrd position in the rank order. In case of non-beneficiary respondents the observation of data in table indicate that the constraints

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pertaining to heading/weeding were perceived with high severity (MPS 105.33) followed by constraints pertaining to breeding (MPS104.33) and feeding aspects (MPS 104.10) of livestock management.

Analysis of the table further indicate that the calculated 'Z' value for all the three major aspects were found to be greater than the tabulated value at 1% level of significance. It could be inferred therefore that there existed a difference in the constraints perceived by the beneficiaries and non -beneficiaries in getting the benefits of "Gopal Yojna" in the study.

Conclusion

It could be concluded from the above discussion that charging of high prices for AI, unavailability cost effective green fodder in the area, and high charges for treatment of animals were the priority constraints experienced by both beneficiary and non-beneficiary animal keepers in Girwa panchayat samiti of Udaipur district of Rajasthan. It is, therefore, recommended that frequent training programs on breeding, feeding heading and weeding aspect of livestock management conducted by the institutions for animal keepers so the constraints can be minimized. Barring this, it is also suggested that government should take steps themselves the responsibilities to supply the needed inputs and fodder at village level. Regular training of Gopal is necessary to make the Gopal Yojana effective so that they may acquire necessary skills in performing various operations.

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Aromatherapy: A holistic healing treatment through flowers– A review

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Abstract

Aromatherapy employs aromatic essential oils for medicinal purposes, aiming to enhance the overall health of the body, mind, and spirit by addressing both physical and emotional well-being. This review delves into existing literature, exploring the therapeutic, medical, cosmetic, psychological, olfactory, and massage aspects of aromatherapy, as well as safety considerations and the diverse range of plants used in this practice.Various administration methods, such as inhalation, massage, or topical applications in small quantities, are employed, with internal consumption being rare. Fundamental to aromatherapy are the practices of inhaling and externally applying essential oils to achieve mental and physical balance. The olfactory nerves, connecting the nose to the brain, serve as the primary site of action for these oils.In contemporary trends, aromatherapy is increasingly utilized in cancer treatment, post-operative pain reduction in pregnant women undergoing caesarean procedures, anxiety alleviation, improved sleep quality for burn injury and dental patients, and addressing sleep disorders. The inherent organic nature of these essential oils, coupled with their ability to synergize with the body, imparts a sense of well-beingness. As the therapeutic landscape expands, it is essential to acknowledge aromatherapy as a

complementary approach, promoting holistic health and augmenting conventional medical interventions.

Top of Form

Key words: Aromatherapy, Essential oil, Flowers, Massage

INTRODUCTION

Aromatherapy, also known as essential oil therapy, is a holistic healing approach utilizing natural plant extracts to enhance overall health and well-being. It involves the medicinal use of aromatic essential oils to benefit the body, mind, and spirit, promoting both physical and emotional health. Considered a form of alternative medicine, aromatherapy harnesses the distinctive aromas found in various plant parts, such as roots, stems, leaves, flowers, and fruits.Perfumes, essential oils, and aromas have historically conveyed religious values, living standards, and personal development, serving as adornments for individuals. Dating back at least 6000 years, ancient civilizations like Egypt, China, and India embraced aromatherapy as a popular complementary and alternative therapy. In the late 20th century and continuing into the

21st century, aromatherapy has gained widespread attention and recognition, evolving into the field of aroma science therapy.The unique flavors and aromas in plant parts result from the presence of essential oils in specialized glands. These oils comprise a mix of saturated and unsaturated hydrocarbons, alcohol, aldehydes, esters, ethers, ketones, oxides, phenols, and terpenes, creating distinct odors. Essential oils are found in pockets, reservoirs, glandular hairs, specialized cells, or intercellular spaces within plants. The release of essences from plants not only shields them from bacterial attacks but also provides a warming aura protecting them from temperature fluctuations.Aromatherapy employs various administration methods, including inhalation, massage, skin applications with carrier lotions, bathing, and compresses, all in small quantities. The integration of aromatherapy into holistic medicine has seen significant progress in recent years. Extensive research has explored its effects on the human brain and emotions, including its impact on mood, alertness, and mental stress in healthy individuals.Studies have delved into aromatherapy's influence on work ability, reaction time, and spontaneous actions through electroencephalograph patterns and functional

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imaging studies. The therapy has demonstrated positive outcomes in reducing pre-menstrual symptoms, postoperative pain in cesarean cases, depression in postmenopausal women, anxiety and stress in hemodialysis patients, and enhancing short-term memory. The olfactory bulb transmits signals to the limbic and hypothalamus parts of the brain, prompting the release of neurotransmitters like serotonin and endorphins, facilitating communication across nervous and body systems to bring about desired changes and a sense of relief. Calming, euphoric, and stimulating oils release serotonin, endorphins, and noradrenaline, respectively, contributing to the anticipated effects on the mind and body.

HISTORY OF AROMATHERAPY: MYTHICAL, MAGICAL AND MEDICINAL

Ancient Egyptian had great knowledge of cosmetology, ointment and aromatic oil. Cleoptara used herbal oils in her beauty regiment. Plant essence were used in mummification process. China first recorded the use of aromatic oil around 2700 BC. during the yellow emperor Huang ti's dynasty. His 'book of internal medicine' Contain the use of many aromatics still used today. Early Romans utilized many benefits of aromatic infused oil in their daily lives and even in sporting event applying perfume oil lavishly on their bodies, bedding and clothes.Early Greeks adopted the knowledge of essential oil from the egyptians. 'Hippocrates' the father of medicine documented the effect of some 300 plants. India is famously known for its healing tradition from ayurveda which date backs thousands of year and which includes using herbal infusion and essential oil.

WHAT IS ESSENTIAL OIL?

Essential oils are highly concentrated hydrophobic liquids that encapsulate the volatile aroma compounds derived from plants. These oils, alternatively referred to as volatile oils, ethereal oils, aetherola, or simply the "oil of the plant," are extracted through various methods.

HOW DO ESSENTIAL OILS WORK?

The olfactory system encompasses all physical organs or cells associated with the sense of smell. When we breathe in through the nose, airborne molecules interact with the olfactory organs, reaching the brain almost instantly. As odor molecules journey through the nasal passages, they impact the brain by activating various receptor sites, including those in

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the limbic system, commonly known as the "emotional brain." The limbic system has direct connections to brain regions that regulate heart rate, blood pressure, breathing, memory, stress levels, and hormone balance. This intricate connection sheds light on why certain scents often evoke emotional responses. Armed with this understanding, we can hypothesize about the profound physiological and psychological effects that may result from inhaling essential oils (Fig. 1).

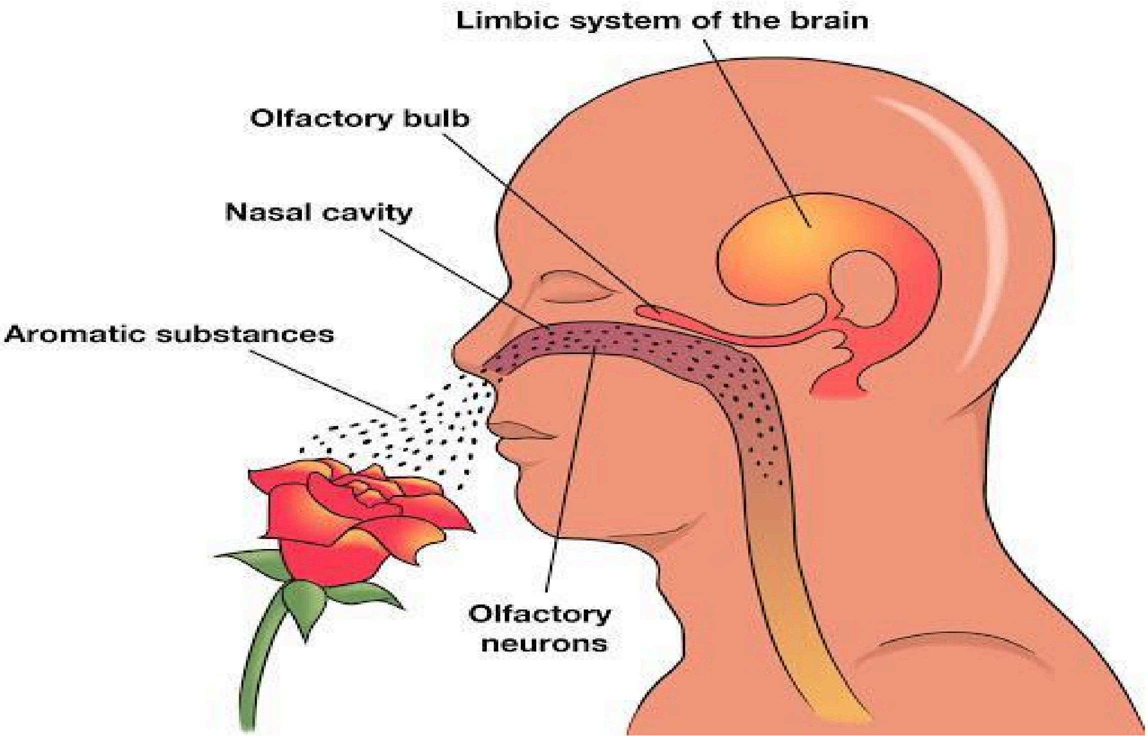

Fig. 1: Science behind aromatherapy
[Source: nuworldbotanicals.com]

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FLOWER BASED ESSENTIAL OILS

Essential oil	Chemical components
Rose oil	Phenyl ethyl alcohol, nerol, geraniol, citronellol, demascenone
Jasmine oil	Benzyl acetate, indole, cis-jasmone and methyl jasmonate
Tuberose oil	Methyl benzoate, Methyl anthranilate, benzyl alcohol, butyric acid, nerol, geraniol, eugenol, farnesol
Spider lily oil	Benzyl Alcohol, Beta Myrcene, 3-Carene or Camphene or ocimene, Beta Pinene, Camphene or Limonene, Trans-Citral or Cis-Citral, Linalool Acetate, GeranylFormate, Isocaprolactone or Dihydro-3,5-Dimethyl-2-(3H)-Furanone
Marigold oil	Limonene, Tagetone, Linalool, Ocimenone
Pot marigold (Calendula) oil	Ester, Calendulin, triterpendiol ester, faradiol esters
Geranium oil	Dimethyl sulphate, ethyl alcohol, diacetylpinayl, linalool, terpineol
Lotus oil	Linalool, terpenen 4-01, 1,8 cineole, 1,4 –Dimethoxybenzene
Sage oil	Linalool, linalyl acetate
Plumeria oil	Limonene, Phynel acetaldehyde, αfarnesene
Magnolia oil	16 eudesmol, cadinol, guaiol
Champaka oil	Linalool, methyl eugenol, methyl ester
YlangYlang oil	Linalool, methyl eugenol, methyl ester
Lavender oil	Linalool, linalyl acetate, ethylphenyl acetate
Chamomile oil	pinene, camphene, b-pinene, sabinene, myrcene, y-terpinene, caryophyllene, and propyl angelate and butyl angelate.
Verbena oil	Limonene, 1,8-cineole, caryophyllene oxide, spathulenol

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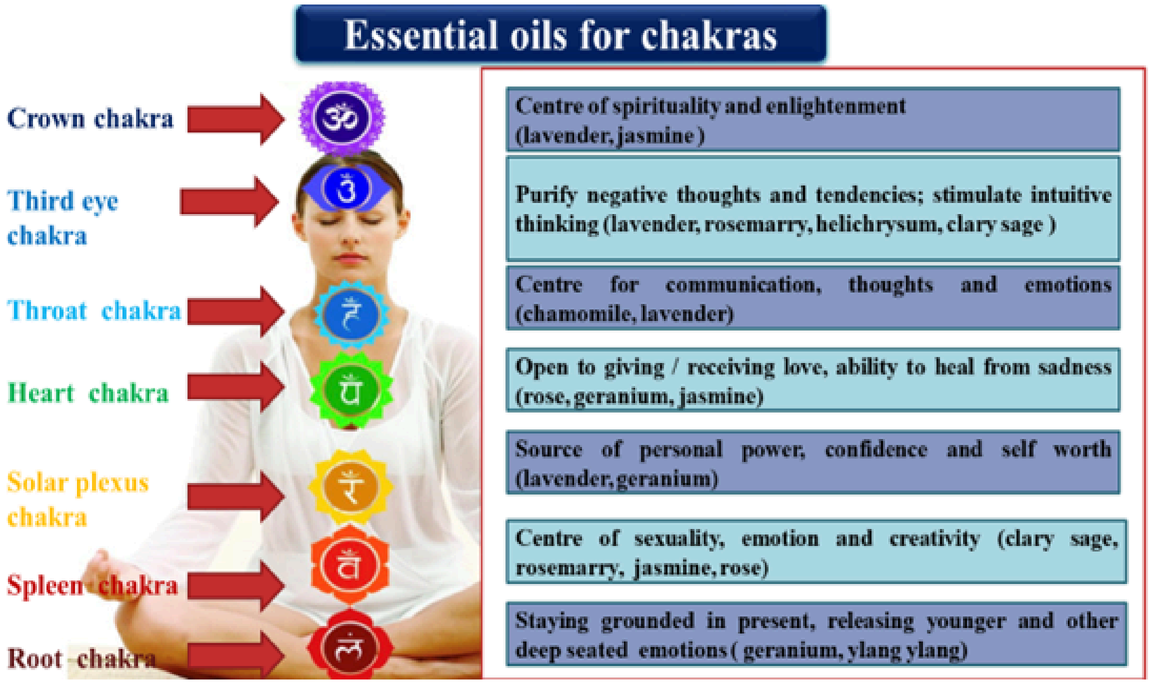

Fig. 2: Essential oil for chakras
[Source: https://jadebalden.com]

❖ APPLICATION IN AROMATHERAPY

Aromatherapy derives its name from "aroma," signifying fragrance or smell, and "therapy," denoting treatment. It is centered around the use of aromatic materials, including essential oils and other aroma compounds, with purported benefits for enhancing psychological and physical well-being (Sayowan et al., 2013). Essential oils, owing to their distinctive aromas, are employed for promoting psychological and physical health through inhalation, impacting brainwaves and influencing behavior.

The olfactory properties of essential oils elicit both objective and subjective effects on cognitive performance and mood, respectively. Various plants, such as Clary sage, Eucalyptus, Geranium, Lemon, Lavender, Peppermint, Rosemary, Roman chamomile, Tea tree, and Ylang ylang, have been historically utilized in aromatherapy due to the presence of essential or volatile oils in different plant materials like flowers, bark, stems, leaves, roots, and fruits.

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CLASSIFICATION OF AROMATHERAPY:

- **Cosmetic aromatherapy:** This application involves using specific essential oils in skin, body, face, and hair cosmetic products. These oils contribute to various effects, such as cleansing, moisturizing, drying, and toning, promoting healthy skin when incorporated into facial products.
- **Massage aromatherapy:** Utilizing grape seed, almond, or jojoba oil in pure vegetable oil during massages has demonstrated remarkable effects, enhancing the overall massage experience.
- **Medical aromatherapy:** Pioneered by modern aromatherapy founder Rene-Maurice Gattefosse, this category involves using essential oils to massage patients during surgery, leveraging the medicinal knowledge of essential oils for promoting and treating clinically diagnosed medical conditions.
- **Olfactory aromatherapy:** Focused on inhalation, olfactory aromatherapy enhances emotional wellness, calmness, relaxation, or rejuvenation through the pleasurable scents of essential oils. The release of stress is intertwined with the unlocking of odor memories.
- **Psycho-aromatherapy:** This category explores the emotional states achieved through essential oils, providing relaxation, invigoration, or pleasant memories. The direct inhalation of oils is the primary method, either through personal application or room infusion. Psycho-aromatherapy and aromacology both study the effects of aroma, whether natural or synthetic, with psycho-aromatherapy specifically concentrating on natural essential oils.
- **Mode of application of aromatherapy**

1. Bathing

Incorporating oils into your bath is a simple way to harness their health benefits. Just add a few drops to your bathwater, mix it in, and immerse yourself. The aroma not only enhances circulation but also contributes to achieving physical balance.

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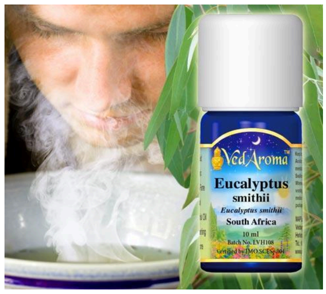
2. Massage

Perhaps the most effective application method is through massage. Combining drops of oil with a carrier lotion can have both psychological and physiological effects on the body.



3. Vapour inhalation

Since numerous aromatic oils are believed to relieve sinus or respiratory issues, steam inhalation is a widely favored method. A general guideline for many oils is to add 5 drops to steaming water and inhale the aroma by creating a tent with a towel.

4. Lotion/creams

Add a few drops of aromatic oil to you favourite carrier lotion, massage oils or cream such as cocoa butter, shea butter or an unscented lotion base to create your own fragrant blend, to stimulate healing properties.

5. Compress

Place a few drops of your preferred oil into a bowl of warm water. Submerge a washcloth into the blend, wring it out, and use the washcloth as a compress. Apply it to the area of the body requiring pain relief, such as the stomach, forehead, or muscles.

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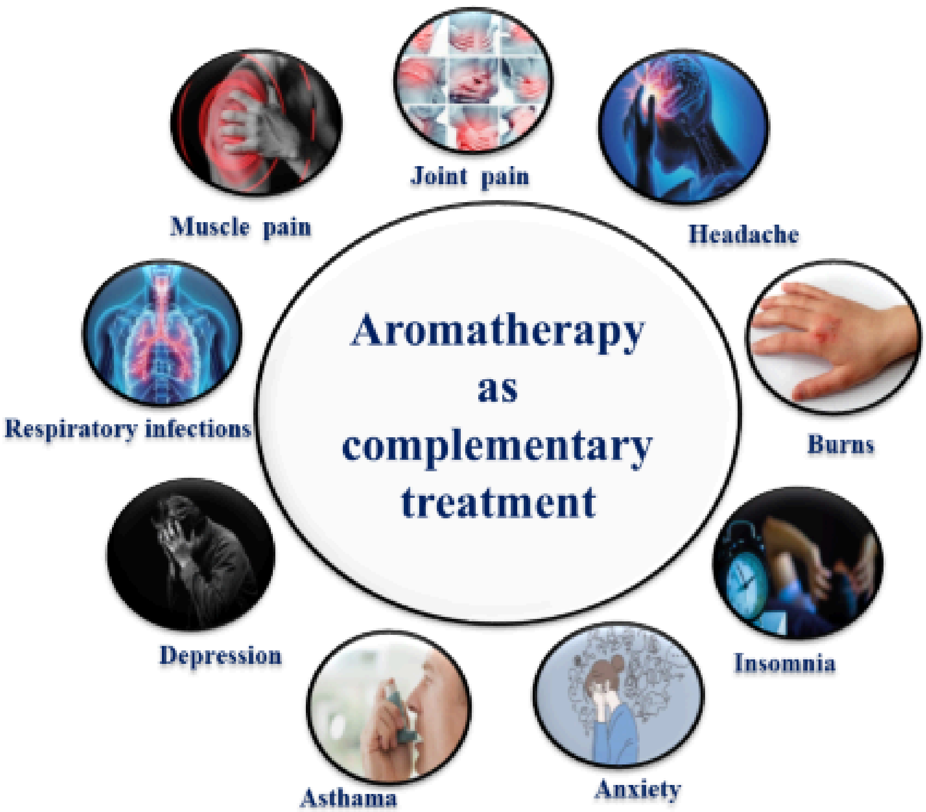

❖ Caution for using essential oil

- Essential oils should not be used in concentrated form. As a general rule the concentration level of essential oils should be below 5 %
- Patch test before using essential oil is necessary
- While using essential oil least amount should be used, blending a few drops of essential oil with carrier oil

- Beware of the false products
- Practice aromatherapy only under a qualified aromatherapy practitioner
- Not to be used for babies or young children expect chamomile oil

Research study on various flower crops

Jasmine

According to Tapanee (2010) 1 ml of 20 % (w/w) solution of jasmine oil massage for 5 minutes resulted significant increase in subjective emotional behavior *i.e.* more alertness, vigor and less relaxation as compared to control group, stimulatory effects on the function of nervous system and increased beta wave power (13 – 30 Hz) in the anterior centre as well as the left posterior region and positive emotions with respect to the feeling of well – being,

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active, fresh and romantic have been increased and the negative emotion like feeling drowsy was significantly decreased in participants [Sayowan*et al.* (2013)].

Lavender

Inhalation of lavender oil 10 % (v/v) sifgnificantly decreased systolic blood pressure (108.0 mmHg), diastolic blood pressure (68.52 mmHg), heart rate (65.68 bpm) and skin temperature (31.0 0 C) of 20 healthy personsaccording to Sayorwan*et al.* (2012),10 % lavender essence inhalation for 5 minutes reported 90 % satisfaction in caesarean post-operative pain than placebo group (50 % satisfaction) [Olapour*et al.* (2013)],decreased anxiety score with an increasing age of dental patients [Venkataramana *et al.* (2016)].

Geranium

Aromatherapy massage through 2 % geranium essential oil blending in sweet almond oil for 30 minutes found beneficial for reduction of depression symptoms in postmenopausal women [Lotfipur-Rafsanjani *et al.* (2015)] while using damask rose essential oil on depression, anxiety and stress in hemodialysis patients and reported that inhalation of damask rose oil in aromatherapy decreased the level of depression, anxiety and stress in hemodialysis patients [Dehkordi*et al.* (2017)].

Sweet Almond

According to Lotfipur-Rafsanjani *et al.* (2018), aromatherapy massage using blend of 2 % geranium essential oil and sweet almond oil decreased physical and mental symptoms of premenstrual syndrome (PMS) as compared to massage therapy and control.

Rosemary

Sulung and Aulia (2018) revealed that rosemary aromatherapy significantly improved short term memory score (26.50) than pre-treatment score (24. 31) of the elderly.

Frangipani (Plumeria)

Effect of massage treatment using frangipani (Plumeria) essential oil aromatherapy for reducing the pain after childbirth. They observed that after receiving aromatherapy massage severe pain intensity (7 – 9 pain scale) was decreased from 97.14 % to 45.71 % and moderate pain intensity (4 – 6 pain scale) was increased from 2.86 % to 54.29 % which was converted from severe pain to moderate pain in women after giving child birth [Sriasih*et al.* (2019)].

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Lavender + Chamomile

The effectiveness of aromatherapy massage using lavender and chamomile oil on the anxiety and sleep quality of burn patients was evaluated by Rafii *et al.* (2020). They observed that aromatic oil massage using lavender and chamomile oil for 20 minutes significantly reduced anxiety score (42.27 ± 3.25) and improved sleep quality (8.45 ± 3.24) in patients with burn injury.

Conclusion

From the foregoing discussion it can be concluded that, aromatherapy regulates the physiological, spiritual and psychological upliftment for the new phase of life. Inhalation of lavender oil in aromatherapy helps to decrease blood pressure, heart rate and skin temperature in human. Moreover, lavender essential oil helps to reduce post-operative caesarean pain in pregnant women as well as decrease the anxiety level and improve sleep quality in patients having burn injury and dental problems. Use of jasmine essential oils in aromatherapy enhanced beta wave power in brain and thereby increased positive emotions in human. Aromatherapy with 2 % geranium oil was found effective for reduction of depression symptoms in post-menopausal as well as premenstrual syndrome in women. Depression anxiety and stress can be reduced by use of damask rose oil inhalation. Short term memory can be improved in elder person by using rosemary oil through aromatherapy. Frangipani (Plumeria) oil massage in aromatherapy reduced the child birth pain intensity in pregnant women. This therapy is not only preventive but also can be used in the acute and chronic stages of disease.

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