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Influence of tapping position, intensity of tapping and season on gummosis of guggal (*Commiphora wightii*), oleo-gum-resin yield and quality

JATINDRA NATH SAMANTA[1], KUNAL MANDAL[2], RAJU SARAVANAN[3],
NARENDRA ATMARAM GAJBHIYE[4] and VELUMANI RAVI[5]

ICAR-Directorate of Medicinal and Aromatic Plants Resarch, Anand, Gujarat 387 310

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ABSTRACT

The experiment was conducted during 2009 and 2010 to find out different tapping position on the guggal plant [*Commiphora wightii* (Arn.) Bhand.] with varying intensity of tapping to maximize the gum production and tested them at different seasons to know the gum production potential as well as the quality changes with respect to different seasons. Favourable soil moisture and plant water status critically enhanced physiological functions which resulted in higher energy status, sap flow and turgor to enable gum oozing without break. Multiple tapping at different locations proved to be superior to single tapping. To maximize guggal yield, multiple tapping is needed at the right season. Wound created during tapping on the bark promoted wound response by inducing the resin ducts to release the oleo-gum to seal the wound.

Key words: Guggal, Gummosis, Oleo-gum-resin yield, Season, Tapping

The indigenous technique of guggal [*Commiphora wightii* (Arn.) Bhand.] gum extraction involves making multiple bark–deep incisions on the stems of trees and use a suspension or slurry of guggal gum to flood the injured area (Mandal *et al*. 2011). Gum starts oozing after few days from these sites. There is a causal link between infection of pathogenic bacterium *Xanthomonas auxonopodis* introduced during tapping of stem and gum exudation in guggal (Samanta and Mandal 2014, Samanta *et al*. 2012). The tapped trees die invariable due to the infection. It was postulated that plant death following gum oozing could be due to physiological disturbances or involvement of pathogens in the process (Samanta and Mandal 2014). Bacterial infections in plant tissue lead to localized wound responses and hence, the induction of oleo gum resin production in response to such infection might be localized in the stem tissue while tapping. Since, guggal is a slow growing species and it takes at least 5-6 years for the plants to attain tapping maturity, death of the plant after tapping becomes a severe limitation to guggal gum production. There is an urgent need to utilize the gum extraction to the fullest potential from each tree before it dies. It would be possible to increase the quantum of gum production by multiplying gum oozing sites on guggal plant through repeated wounding. With this aim, we tried different tapping position on the plant with varying intensity of tapping to maximize the gum production and tested them at different seasons to know the gum production potential as well as the quality changes with respect to different seasons. Our results were encouraging in terms of higher gum production and we could identify the seasonal effect on gum quality.

MATERIALS AND METHODS

Bacteria associated with plant material were isolated by standard methodology (Samanta *et al*. 2012) and utilized for induction of gummosis. The experiment was conducted during 2009 and 2010 at the research farm of Directorate of Medicinal and Aromatic Plants Research (22^o 35' N, 72^o 56' E).

For the study on effect of seasons on gum yield and quality, field-grown plants (>5 years old, $r = 4$) were tapped in four different seasons—post winter (February), summer (May), post–rainy (September) and winter (December)—with ~108 cfu/ml bacterial suspension. Gum was collected from the tapped positions and yield was recorded. To study the influence of different tapping positions (main trunk, M; primary branch, P; secondary branch, S and tertiary branch, (T) on gum yield, of mature guggal plants (>7 years old) were tapped to as explained earlier. Each tree was considered as a replication and 10 replications were maintained for each treatment. In another experiment, five different treatments, comprising different combinations of tapping sites were maintained. Individual plants were tapped

[1]Executive R & D (Microbiology) (e mail: jatinsamanta@gmail.com.), [2]Principal Scientist (e mail: mandal_kunal@yahoo.co.in), ICAR-CRIJAF, Kolkata; [3]Senior Scientist (e mail: rajusar@gmail.com), [5]Principal Scientist, ICAR-CTCRI, Thiruvananthapuram, Kerata; [4](e mail: gajbhiye_narendra@yahoo.co.in), ICAR-DMAPR, Anand, Gujarat.

at T1: 2 positions (P+P); T2: 3 positions (P+S+S); T3: 4 positions (P+P+S+S); T4: 4 positions (M+P+S+S); and T5: 5 positions (M+P+P+S+S). Three replications were maintained for each treatment in this experiment. Two months after inoculation the accumulated gum was collected, weighed, and yield per plant was noted.

Plant water potential (Y_w) was measured with a pressure chamber (3005 Pressure Extractor, Soil Moisture Equipment Corp., Santa Barbara, CA, USA) during active photosynthesis period (10.30–12.30 h). For the measurement of water potential, a terminal twig (15 cm long) was removed from each plant. Immediately its cut end was smoothened with a sharp transverse cut and 2 mm length of bark at this end was removed as latex from the bark often interfered with taking readings. The twig was inserted inside the pressure chamber in such a way that ~3 cm of the cut end remains outside and slowly air pressure was increased with nitrogen gas flow. Pressure at which xylem sap flow was initiated at the cut end was noted as the Y.

Phytochemical analysis of gum was performed using HPLC using authentic guggalsterone–E and –Z standards. The HPLC system (M/s Waters, Milford, MA, USA) consisted of a RP–18 column (250 mm × 4.6 mm, 5 ìm, LiChrospher, Merck), Delta 600 quaternary gradient pump, 600 system controller, 2669 PDA detector and Empower software. A mixture of methanol and water (65:35 v/v) was used as mobile phase at a flow rate of 1ml/min. The compounds were monitored at 245 nm.

Data were subjected to analysis of variance (ANOVA) using R programme (RStudio, USA). Means were compared with least significant difference (*P*=0.05). Data from two repetitions of the experiment were analyzed separately and an average data from one experiment are presented here as results from both the experiments followed similar trend.

RESULTS AND DISCUSSION

Seasonal influence and plant water relationship on guggal yield

Guggal plant growth pattern, leaf production and canopy coverage varied with seasons. As expected, the results of tapping at different seasons clearly demonstrated that seasons greatly influenced the gum yield and quality of oleo-gum. Plants tapped in the month of September produced the highest gum (49.4±3.4 g/plant), while it was the lowest in plants tapped during May (3.1±0.6 g/plant). December and February tapping produced similar gum yields. The plant water potential (Y_w) was significantly different during growth phases and influenced by the season (Fig 1). Post monsoon period had the highest soil moisture content (12-13%) as well as lowest Y_w (~ 0.8 MPa), whereas, during the month of May the soil water potential was lowest with relatively moderate Y_w (~ 0.6 MPa). December and February tapping coincided with higher Y_w (0.4 MPa to 0.6 MPa). Guggal gum yield in different seasons was indirectly influenced by the soil moisture content. The gum yield at different seasons showed positive correlation with soil moisture level (Fig 2A). the month of May was characterized by very low soil moisture and the least quantity gum production. Whereas, the month of September had higher soil water with highest gum yield (Fig 2B). December and February tapping resulted in intermediate gum yields which were lower than that of the September and significantly higher than that of the May. The Y_w and seasonal gum tapping indicated a clear pattern of lower gum yield with lower plant water status (Fig 2 C). Although the individual plants showed variations in terms of gum yield during September tapping, the gum yield was superior compared to other seasons.

Intensity and tapping position on gum yield

From a single portion of stem, the highest gum yield (81.1±15.1 g/plant) was obtained at the collar region of the main branch, while tapping on twig produced the lowest

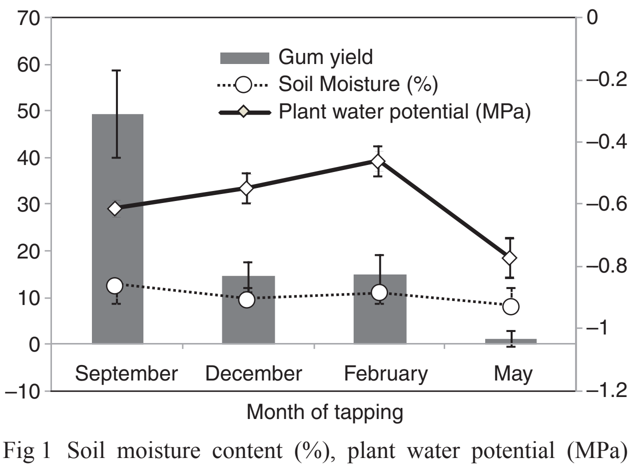


Fig 1 Soil moisture content (%), plant water potential (MPa) and guggal gum yield during different tapping seasons

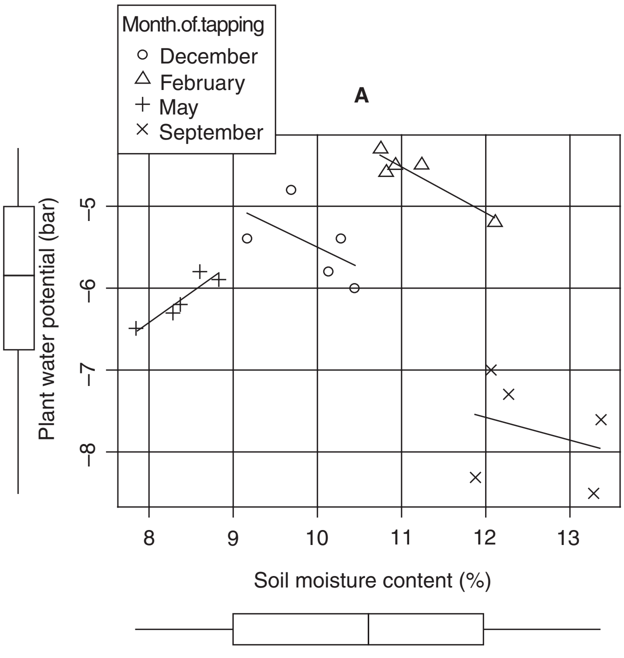
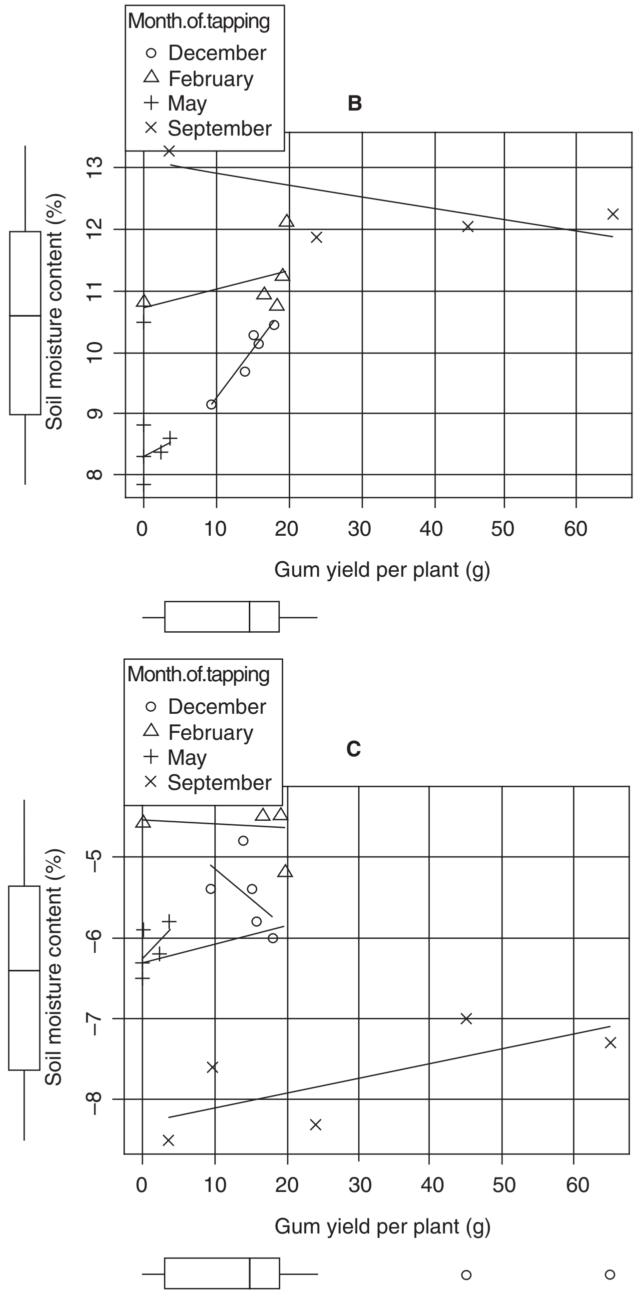


Fig 2 Correlation matrix of plant water potential with soil moisture content (A), gum yield with soil moisture content (B) and gum yield with plant water potential (C)in guggal during different tapping seasons.



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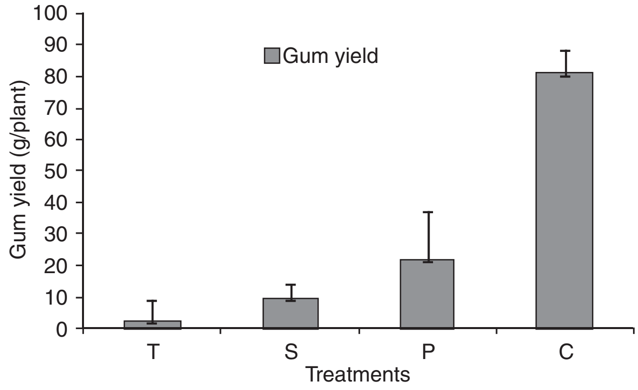

Fig 3 Influence of tapping position on guggal gum yield (T - Tertiary branch, P - Primary Branch, S - Secondary Branch and C - Collar region).

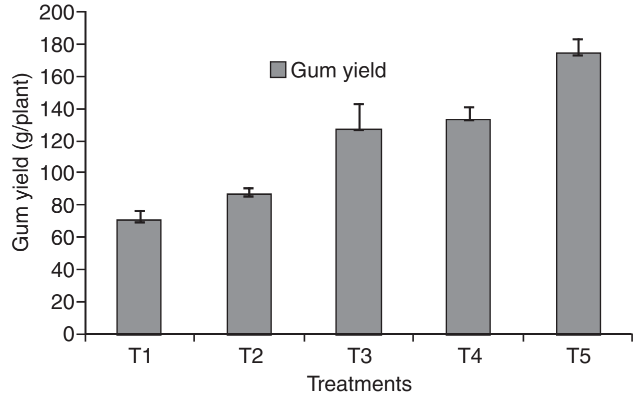

Fig 4 Influence of multiple tapping of guggal gum yield T1 - 2 positions (S+S), T2, 3 positions (S+S+P), T3 ,4 positions (S+S+P+P), T4 - 4 positions (C+P+S+S) and T5 - 5 positions (M+P+P+S+S).

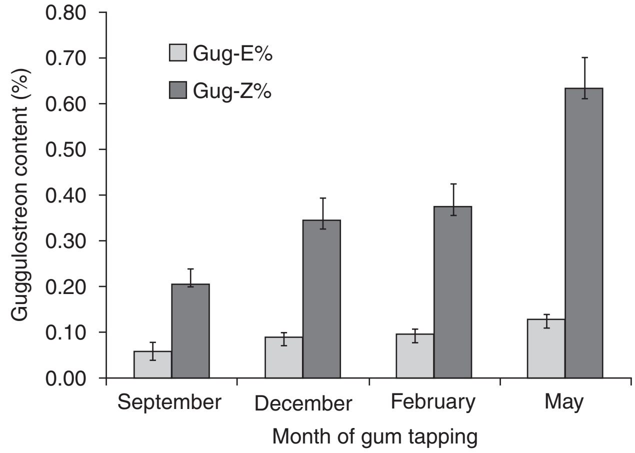

Fig 5 Effect of different tapping season on guggulostre ron content of guggal gum.

gum (2.7±0.7 g/plant) (Fig 4). Profuse gummosis after tapping of the main stem and primary branches resulted in continued gum exudation which lasted for a fortnight before cessation of gum production. The bark thickness and amount of resin ducts per unit area might have contributed to the higher gum exudation on main stem. Plants tapped at five positions (T5) produced the highest gum (175.0±9.0 g/plant), while it was the lowest when tapped at two primary branches (71.0±6.6 g/plant) (Fig 5).

Influence of season on guggal quality

Guggal gum composition in terms of gugglostreon–Z and gugglostreon–E significantly varied due to the season of tapping. Seasonal influence followed increasing trend towards the drier months starting from September tapping which was immediately followed the monsoon. There was a greater varitation in gugglostreon–Z compared to gugglostreon–E. The content of gugglostreon–Z varied from

0.2% during September tapping to 0.6% in the (3 fold) month of May. The change in gugglostreon–E content in the oleo-gum resin was not appreciable in different tapping seasons.

September tapping coincided with post-monsoon growth flush of guggal with maximum canopy coverage and higher plant photosynthetically active phase. The transpiration demand was also high during this period due to higher leaf area. During the December and Febraury tapping, the soil moisture depletion did not lead to severe stress due to the natural adaptation of guggal to prolonged soil moisture depletion. However, during the summer months of April and May posed extreme stress situation due to lower soil moisture, high ambient temperature coupled with high solar radiation. When drought is prolonged Oleoresinosis in trees such as, pine and fir is reduced owing to lower substrate and/or energy availability (Lorio 1988). The Y_W was reduced markedly due to the complete canopy cover and larger leaves immediately after monsoon. Guggal sheds leaves during winter and produces smaller leaves in dry seasons to conserve water. The higher photosynthetic potential during post monsoon was partly responsible for increased gum yield.

Tapping during the month of December and February coincided with higher water status of guggal due to lower transpirational demand. Plant water potential remained favorable during these months due to winter season. Samanta *et al.* (2012) indicated that higher guggal growth rate and oleo-gum resin yield could be achieved by maintaining soil moisture levels between field capacity and 20%. Drought has differential influence on above- and underground growth of plants and profound negative effect on shoot growth (Xu *et al.* 2009, Álvarez *et al.* 2011). Loblolly pine which produces resin when induced, produce lower resin when extreme drought stress occurs during late summer season (Lorio and Hodges 1968, Lorio *et al*. 1995, Lombardero *et al*. 2000). Extreme water deficits can ultimately lead to a collapse of the carbon allocation to secondary metabolism (Herms and L Mattson 1992). Induced increases in resin flow of pine trees, however, were greatest in the fastest growing trees during the season of greatest growth and decreased during stress conditions (Lombardero *et al.* 2000).

Favorable soil moisture and plant water status critically enhanced physiological functions which resulted in higher energy status, sap flow and turgor to enable gum oozing without break. May was the hottest month tested for tapping and many plants, which were otherwise productive failed to produce gum. Multiple tapping at different locations proved to be superior to single tapping. Wound created during tapping on the bark promoted wound response by inducing the resin ducts to release the oleo-gum to seal the wound. Since, wound response can be localized or systemic, it will be interesting to understand the extent of these local or systemic responses contribute to the gummosis of guggal. To maximize guggal yield, multiple tapping is needed at the right season. Tapping at multiple sites of a same tree is practiced in other species such as, *Boswellia papayrifera* to maximize gum yield (Mengistu *et al.* 2012). Since, guggalstreone is the active constituent of guggal, any increase in its content indicates positive influence and improvement in quality of guggal.

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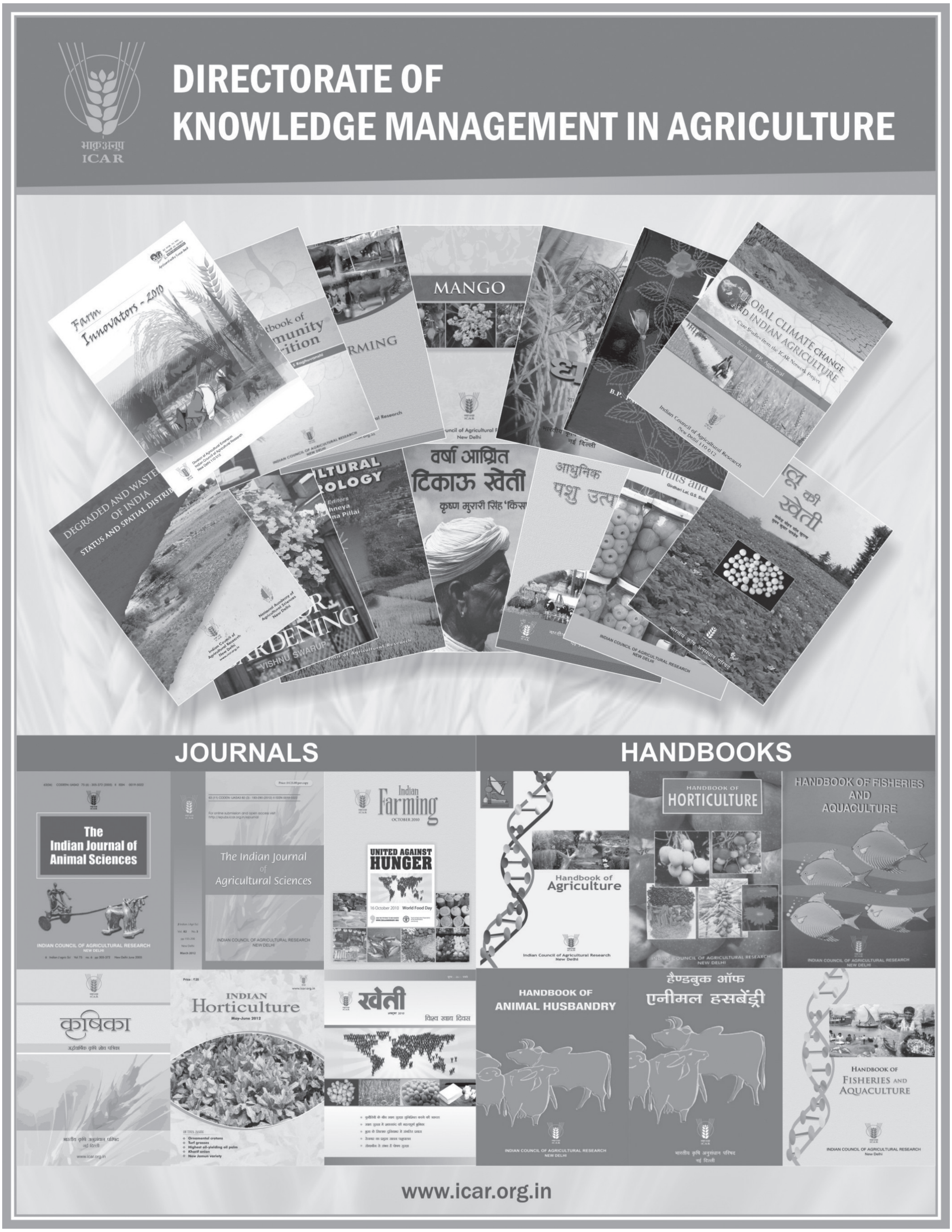
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