TABLE I

Percentage of α- and β- forms of BOAA in low and high BOAA containing L. sativus *seeds and corresponding seedlings*

Sample No.*	% BOAA*	In seeds β form as % of total	In seedlings β form as % of total
I. BOAA Low Variety			
247	0·20	95·0	96·1
2	0·12	89·7	96·3
10	0·25	94·3	95·8
32	0·26	93·0	93·6
24	0·25	90·4	97·0
13	0·12	90·0	94·7
Average	0·19	92·06	95·6
β-isomer = 92·06%		β-isomer = 95·6%	
α-isomer = 7·94%		α-isomer = 4·4%	
II. BOAA High Variety			
S-38	2·25	93·8	95·5
S-90	2·13	97·3	94·4
S-13	2·13	95·2	94·3
S-83	2·13	96·1	97·8
S-102	2·00	97·7	98·5
BGT-200	2·00	95·7	97·1
Average	2·10	95·9	96·2
β-isomer = 95·9%		β-isomer = 96·2%	
α-isomer = 4·1%		α-isomer = 3·8%	

* Samples and analytical data were kindly supplied by Dr. V. Nagarajan.

constant. The β-isomer in "high" and "low" BOAA-containing varieties of *L. sativus* ranged between 92 and 96% of the total BOAA, while α-isomer was very low (4-8%) in the samples studied. The process of germination did not alter the relative proportions of α- and β-isomers.

Thanks are due to Dr. C. Gopalan, Director of these Laboratories, for his constant interest in this investigation, and to Dr. P. G. Tulpule for critically going through the manuscript.

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ON THE FLOW OF A CONDUCTING FLUID IN A ROTATING STRAIGHT PIPE

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CONSIDER a weakly conducting fluid flowing through a straight pipe, walls $z = \pm L$, under the action of a constant pressure gradient $-\partial\Pi/\partial x$ in the direction of x-axis. H_0 is a uniform magnetic field imposed along z-axis and the walls rotate with an angular velocity Ω about the same axis. Assuming that the motion is laminar, the equations of hydromagnetic motion[1] in a rotating frame of reference (stationary relative to the walls) for an incompressible fluid in terms of the complex velocity field $q(z,t) = u + i\ v$ is

$$\frac{\partial q}{\partial t} + 2i\Omega q = -\frac{1}{\rho}\frac{\partial \Pi}{\partial x} + \nu\frac{\partial^2 q}{\partial z^2} - mq, \quad (1)$$

where

$$\Pi = p - \frac{1}{2}\rho\Omega^2(x^2+y^2),\ m = \frac{\sigma\mu^2 H_0^2}{\rho}. \quad (2)$$

We assume at $t = 0$, $q = 0$. The motion is caused by sudden change of pressure gradient from zero to a constant quantity P at $t = 0$. We represent

$$-\frac{1}{\rho}\frac{\partial \Pi}{\partial x} = \mathrm{PH}(t) \quad \text{at} \quad t = 0, \quad (3)$$

where H is a Heaviside's unit function.

We seek the solution of (1) subject to the conditions for no slip at the walls.

$$q = 0 \quad \text{for} \quad t > 0 \quad \text{at} \quad z = \pm L. \quad (4)$$

Using the Laplace transform technique, we find that the solution $\bar{q}$ of the transformed differential equation satisfies,

$$\bar{q} = -\frac{\mathrm{P}\,ch\,\sqrt{(s+m+2i\Omega)/\nu}\,z}{s(s+m+2i\Omega)\,ch\,\sqrt{(s+m+2i\Omega)/\nu}\,\mathrm{L}} + \frac{\mathrm{P}}{s(s+m+2i\Omega)}. \quad (5)$$

On inversion and separating real and imaginary parts, we get

$$u = u_{st} + \sum_{j=1,3,\cdots}^{\infty} \frac{16PL^3}{j\pi r} \exp. \left\{ -\left(\frac{\pi^2 j^2 \nu}{4L^2} + m\right) t \right\} (-1)^{(j+1)/2} \cos(2\Omega t + \theta) \cos \frac{\pi j z}{2L}, \tag{6}$$

$$v = v_{st} + \sum_{j=1,3,\cdots}^{\infty} \frac{16PL^3}{j\pi r} \exp. \left\{ -\left(\frac{\pi^2 j^2 \nu}{4L^2} + m\right) t \right\} . (-1)^{(j-1)/2} \sin(2\Omega t + \theta) \cos \frac{\pi j z}{2L}, \tag{7}$$

where

$$u_{st} = \frac{Pm}{m^2 + 4\Omega^2} - P \frac{\{ch\alpha L \cos\beta L\,(m\,ch\alpha z \cos\beta z + 2\Omega\,sh\alpha z \sin\beta z) + sh\alpha L \sin\beta L\,(m\,sh\alpha z \sin\beta z - 2\Omega\,ch\alpha z \cos\beta z)\}}{\{(m^2 + 4\Omega^2)(ch^2\alpha L \cos^2\beta L + sh^2\alpha L \sin^2\beta L)\}}, \tag{8}$$

$$v_{st} = -\frac{2P\Omega}{m^2 + 4\Omega^2} - P \frac{\{(ch\alpha L \cos\beta L\,(m\,sh\alpha z \sin\beta z - 2\Omega\,ch\alpha z \cos\beta z) - sh\alpha L \sin\beta L\,(m\,ch\alpha z \cos\beta z + 2\Omega\,sh\alpha z \sin\beta z)\}}{\{(m^2 + 4\Omega^2)(ch^2\alpha L \cos^2\beta L + sh^2\alpha L \sin^2\beta L)\}}, \tag{9}$$

$$r = \sqrt{(\pi^2 j^2 \nu + 4L^2 m)^2 + 64L^4\Omega^2}, \quad \tan\theta = \frac{8L^2\Omega}{(\pi^2 j^2 \nu + 4L^2 m)}, \quad \alpha + i\beta = \sqrt{\frac{(m + 2i\Omega)}{\nu}} \tag{10}$$

For small t, we obtain from (5)

$$u = \frac{P}{m^2 + 4\Omega^2}[m(1 - e^{-mt}\cos 2\Omega t) + 2\Omega e^{-mt}\sin 2\Omega t] - P\int_0^t e^{-m\tau}\cos 2\Omega\tau$$

$$\sum_{j=0}^{\infty} (-1)^j \left\{ erfc\,\frac{(2j+1)L - z}{2\sqrt{\nu\tau}} + erfc\,\frac{(2j+1)L + z}{2\sqrt{\nu\tau}} \right\} d\tau, \tag{11}$$

$$v = \frac{P}{m^2 + 4\Omega^2}[e^{-mt}\sin 2\Omega t - 2\Omega(1 - e^{-mt}\cos 2\Omega t)] + P\int_0^t e^{-m\tau}\sin 2\Omega\tau$$

$$\sum_{j=0}^{\infty} (-1)^j \left\{ erfc\,\frac{(2j+1)L - z}{2\sqrt{\nu\tau}} + erfc\,\frac{(2j+1)L + z}{2\sqrt{\nu\tau}} \right\} d\tau. \tag{12}$$

The solutions (11, 12) are convergent for all values of time t. For $\nu t < L^2$, two or three terms are needed for a four place accuracy, so that these are useful in this range and not merely for small values of t. For large $\nu t/L^2$, these solutions are slowly convergent and the expressions (6, 7) are the better.

In the presence of rotation, we find that secondary motion is set in when the flow is unsteady. Several of the non-stationary terms in (6, 7) represent damped oscillations. As $t \to \infty$, the flow is determined by the stationary conditions u_{st}, v_{st} given by (8, 9). When $m=0$, we recover the formula in the hydrodynamic case.[2] When $\Omega \to \infty$, such that $P/2\Omega$ remains finite, for $0 \leqslant z < L$,

$$u = \frac{P}{2\Omega} e^{\alpha(z-L)} \sin\beta(L - z), \tag{13}$$

$$v = \frac{P}{2\Omega} \{e^{\alpha(z-L)} \cos\beta(L - z) - 1\}. \tag{14}$$

Similar expressions can be written for $0 \geqslant z > -L$. We note from (13) that the amplitude of u is positive and that the function $\sin\beta(L-z)$ can take $+$ve or $-$ve values. For $\Omega \to \infty$, such that $P/2\Omega$ is finite, the disturbance is confined to regions of order $1/\alpha$ in the vicinity of the walls. Thus we get a boundary layer at the walls whose thickness is of order $\left(\frac{\Omega}{\nu} + \frac{\mu^2 H_0^2 \sigma}{2\rho\nu}\right)^{-\frac{1}{2}}$ and is less than that corresponding to the zero magnetic case. Under the same conditions but $t \to 0$, the argument of $erfc$ corresponding to $j = 0$ in the integrand of (11, 12) shows that there exists a boundary layer at the walls whose thickness is of order $\sqrt{\nu t}$. Thus in a rapidly rotating system at $t = 0$, the boundary layer thickness grows as $\sqrt{\nu t}$ and for $t \to \infty$, it settles down to an order of thickness $\left(\frac{\Omega}{\nu} + \frac{\mu^2 H_0^2 \sigma}{2\rho\nu}\right)^{-\frac{1}{2}}$

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