Jñānābha, Vol. 36, 2006

ON SOME NEW RESULTS INVOLVING HORN FUNCTIONS OF TWO AND THREE VARIABLES ASSOCIATED WITH FOX'S *H*-FUNCTION

By

Shweta Shrivastava* and N.P. Singh

Department of Mathematics

Government Model Science College, Rewa-486001, Madhya Pradesh, India

(Received : March 28, 2006)

ABSTRACT

The aim of this paper is to establish some new results involving Horn-function of two and three variables associated with Fox's H-function. Some specializations, relevant to the present discussion are also discussed.

2000 Mathematics Subject Classification : Pramary 33C65; Secondary 33C60

Keywords : Horn Function, Fox's H-function.

1. Introduction. The H-function introduced by Fox [3] in the form of Mellin-Barnes type integral and symbolically we denote it by

$$H_{p,q}^{m,n}\left[z\left|\begin{matrix}(a_p,\alpha_p)\\(b_q,\beta_q)\end{matrix}\right.\right]=\frac{1}{2\pi w}\int_L \theta^s z^s ds, w=\sqrt{(-1)},$$

where

$$\theta(s)=\frac{\prod_{j=1}^{m}\Gamma(b_j-f_jS)\prod_{j=1}^{n}\Gamma(1-a_j+e_jS)}{\prod_{j=m+1}^{q}\Gamma(1-b_j+f_jS)\prod_{j=n+1}^{p}\Gamma(a_j-e_jS)} \qquad ...(1.1)$$

For further details, existence convergence conditions of $H_{p,q}^{m,n}[.]$, we may refer to Srivastava *et al.* [12, pp. 10-13]

Occassionally in the present paper, we shall find it convenient to use three dots "..." (in the H-function of one variable) to denote that the parameters of H-function in that position are the same as those given by (1.1).

In ths present investigation we also require the following relations :

$$(1-z)^{\beta_1}G_A[\alpha,\beta_1,\beta_2;\alpha;x(1-z),x(1-y)/2,z]=\sum_{m=0}^{\infty}(-x)^m P_m^{(-\beta_1-m,\beta_1+\beta_2-1)}(y),$$

* Address for Correspondesnce : C/o- Dr. B.M.L. Shrivastava, 12/757, Bajrang Nagar, Rewa-486001, M.P.

$$|x(1-z)|<1, |x(1-y)/2|<1, |z|<1. \tag{1.2}$$

$$\sum_{r=0}^{\infty}\frac{(\lambda)_r}{r!}t^r G_A(\lambda+r,\beta_1,\beta_2;\gamma,x,y,z)=(1-t)^{-\lambda}G_A(\lambda,\beta_1,\beta_2;\gamma,x(1-t),y/(1-t),z/(1-t)), \tag{1.3}$$

$$|x|<1, |y|<1, |z|<1 \text{ and } |t|<1.$$

$$(1-x)^{\alpha_1-\beta_1}(1-y(1-x))^{-\beta_2}(1-y(1-x)(1-yz))^{-\beta_3}$$

$$\times G_B\left(1-\beta_1,\beta_1,\beta_2,\beta_3;\gamma_2;\frac{x}{x-1},\frac{y(1-x)}{y(1-x)-1},\frac{y(1-x)(1-yz)}{y(1-x)(1-yz)-1}\right)$$

$$=\sum_{k=0}^{\infty}\frac{(\alpha_1)_k}{(\gamma_2)_k}(yz)^k\ {}_2F_1\left[\begin{matrix}\alpha_1+k,\beta_2+\beta_3+k;\\ \gamma_2+k;\end{matrix}1-z\right]P_k^{(\beta_2+\beta_3-1,-\beta_2-k)}{}_{(1-2y)}. \tag{...1.4}$$

$$=\sum_{r=0}^{\infty}\frac{(\lambda)_r}{r!}t^r G_B(\alpha,\lambda+r,\beta_2,\beta_3;\gamma,x,y,z)=(1-t)^{-\lambda}G_B\left(\alpha,\lambda,\beta_2,\beta_3;\gamma,\frac{x}{1-t},y,z\right), \tag{...1.5}$$

$$|x|<1, |y|<1, |z|<1 \text{ and } |t|<1.$$

$$\sum_{r=0}^{\infty}\frac{(\lambda)_r}{r!}t^r G_C(\alpha,\alpha_1,\lambda+r,\beta_1;\gamma,x,y,z)=(1-t)^{-\lambda}G_C\left(\alpha,\alpha_1,\lambda,\beta_1;\gamma,\frac{x}{1-t},y,\frac{z}{1-t}\right), \tag{...1.6}$$

$$|x|<1, |y|<1, |z|<1 \text{ and } |t|<1.$$

$$\sum_{n=0}^{\infty}\frac{(\lambda)_n}{n!}z^n H_1(\lambda+n,\beta,\gamma,\delta,x,y)=(1-z)^{-\lambda}H_1\left(\lambda,\beta,\gamma,\delta,\frac{x}{1-t},y(1-z)\right), \tag{...1.7}$$

$$|x|<r, |y|<s, 4rs=(s-1)^2.$$

$$(1-z)^{\alpha}H_A(\alpha,\beta,\beta';\gamma,\beta';x(1-z),(x(y-1))/2,z)=\sum_{m=0}^{\infty}\frac{(\beta)_m}{(\gamma)_m}(-x)^m P_m^{(-\alpha-m,\alpha-\gamma-m)}(y), \tag{...1.8}$$

$$|x(1-z)|<r, |x(y-1)/2|<s, |z|<t, r+s+t=1+st.$$

$$(1-x)^{-\alpha}H_4\left(\alpha,\beta,\gamma,\delta;-xy/(1-x)^2,-x/(1-x)\right)$$

$$=\sum_{m=0}^{\infty}\frac{(\alpha)_m(\delta-\beta)_m}{(\delta)_m(1+\beta-\delta-m)_m}x^m H_m^{(\beta-\delta-m,-m-\beta)}(\alpha+m,\gamma,y), \tag{...1.9}$$

$$\left|xy/(1-x)^2\right| < r, \left|x/1-x\right| < s; 4r = (s-1)^2.$$

$$\sum_{n=0}^{\infty} \frac{(\lambda)_n}{n!} z^n H_6(\lambda+n,\gamma,x,y) = (1-z)^{-\lambda} \sum_{r=0}^{\infty} \frac{(y/(1-z))^r}{(\gamma)_r} \psi_r\left(\lambda, \frac{x}{y(z-1)}\right), |x| < 1/4 \qquad ...(1.10)$$

$$\sum_{n=0}^{\infty} \frac{(\lambda)_n}{n!} z^n H_7(\alpha,\lambda+n,\gamma,\delta,x,y) = (1-z)^{-\lambda} H_7\left(\alpha,\lambda,\gamma,\delta,x,\frac{y}{1-z}\right), \qquad ...(1.11)$$

$$|x| < r, |y| < s, 4r = (s^{-1}-1)^2.$$

$$\sum_{n=0}^{\infty} \frac{(\lambda)_n}{n!} z^n H_8(\lambda+n,\beta,x,y) = (1-z)^{-\lambda} H_8\left(\lambda,\beta,\frac{x}{(1-z)^2}, y(1-z)\right), |x| < 1/4 \qquad ...(1.12)$$

where G_A, G_B are hypergeometric functions of three variables of Horn's type [5,p.115-116], G_C is triple Hypergeometric function [1,p.47, (4.1)], H_A is triple Hypergeometric function of the second order [13, p.97-108], H_1, H_4, H_6,H_7,H_8 are Horn's functions [2, p.225-226], $H_n^{(\alpha,\beta)}(.)$ are generalised Rice's polynomial [4], $P_n^{(\alpha,\beta)}(.)$ are Jacobi polynomials [6,p.254, (1)] and $\Psi_n(c,x)$ are standard Bessel polynomials [6. p.294].

Equations (1.2), (1.8) are known results given by Shrivatava [9, p.112, (5.5.1) and p.113, (5.5.2)], formulas (1.3), (1.5) and (1.6) are due to Singh and Shrivastava [7, p. 1248-49, (2.1), (2.5) and (2.8)], (1.4) is a tranformation given by Shrivastava [10, p.212, (3.2)], results (1.7),(1.10), (1.11), (1.12) are discussed by Singh and Shrivastava [8, p.63-64 (3.1), (2.2), (3.4) and (3.6)] and (1.9) is a generating function obtained by Shrivastava [11,p.298, (2.2)].

2. Main Results. In this section we establish the following relations:

$$\sum_{l=0}^{\infty} \frac{x^l}{l} H_{p,q+1}^{m+1,n}\left[t\left|\begin{matrix} \cdots \\ (\alpha+l,0),\ldots \end{matrix}\right.\right] H_4\left(\alpha,\beta,\gamma,\delta,\frac{-xy}{(1-x)^2},\frac{-x}{1-x}\right)$$

$$= H_{p,q+1}^{m+1,n}\left[t\left|\begin{matrix} \cdots \\ (\alpha,0),\ldots \end{matrix}\right.\right] \sum_{l=0}^{\infty} \frac{(\alpha)_l(\delta-\beta)_l}{(\delta)_l(1+\beta-\delta-l)_l} x^l H_l^{(\beta-\delta-l,-l-\beta)}(\alpha+1,\gamma,y),$$

$$\left|\frac{xy}{(1-x)^2}\right| < r, \left|\frac{x}{1-x}\right| < s; 4r = (s-1)^2. \qquad ...(2.1)$$

$$\sum_{l=0}^{\infty}\frac{z^l}{l!}H_6(\lambda+l,\gamma,x,y)H_{p,q+1}^{m+1,n}\left[t\left|\begin{matrix}\cdots\\(\lambda+l,0),\ldots\end{matrix}\right.\right]$$

$$=(1-z)^{-\lambda}H_{p,q+1}^{m+1,n}\left[t\left|\begin{matrix}\cdots\\(\lambda,0),\ldots\end{matrix}\right.\right]\sum_{l=0}^{\infty}\frac{(y/(1-z))^l}{(\gamma)_l}\psi_l(\lambda,x/y(z-1)),\ |x|<1/4. \qquad \ldots(2.2)$$

$$\sum_{l=0}^{\infty}\frac{(-z)^l}{l!}H_{p+1,q}^{m,n}\left[t\left|\begin{matrix}\ldots(\beta_1-l,0)\\\cdots\end{matrix}\right.\right]G_A\left(\alpha_1,\beta_1,\beta_2;\alpha;x(1-z),\frac{x(1-y)}{2},z\right)$$

$$=(1-z)^{-\lambda}H_{p+1,q}^{m,n}\left[t\left|\begin{matrix}\ldots(\beta_1-n,0)\\\cdots\end{matrix}\right.\right]\sum_{l=0}^{\infty}(-x)^l P_l^{(-\beta_1-l,\beta_1+\beta_2-1)}(y), \qquad \ldots(2.3)$$

$$|x(1-z)|<1,|(x(1-y))/2|<1,|z|<1.$$

$$(1-y(1-x))^{-\beta_2}(1-y(1-x)(1-yz))^{-\beta_3}$$

$$\times G_B\left(1-\beta_1,\beta_1,\beta_2,\beta_3;\gamma_2;\frac{x}{x-1},\frac{y(1-x)}{y(1-x)-1},\frac{y(1-x)(1-yz)}{y(1-x)(1-yz)-1}\right)$$

$$\sum_{k=0}^{\infty}\frac{x^k}{k!}H_{p,q+1}^{m+1,n}\left[t\left|\begin{matrix}\cdots\\(-\alpha_1+\beta_1+k,\alpha)\ldots\end{matrix}\right.\right]$$

$$=H_{p,q+1}^{m+1,n}\left[t(1-x)^{\alpha}\left|\begin{matrix}\cdots\\(-\alpha_1+\beta_1,\alpha),\ldots\end{matrix}\right.\right]$$

$$\sum_{k=0}^{\infty}\frac{(\alpha_1)_k(yz)^k}{(\gamma_2)_k}\,{}_2F_1\left[\begin{matrix}\alpha_1+k,\beta_2+\beta_3+k;\\\gamma_2+k;\end{matrix}1-z\right]P_k^{(\beta_2+\beta_3-1,-\beta_2-k)}(1-2y) \qquad \ldots(2.4)$$

$$\sum_{l=0}^{\infty}\frac{(-z)^l}{l!}H_{p+1,q}^{m,n}\left[t\left|\begin{matrix}\ldots(\alpha-l,0)\\\cdots\end{matrix}\right.\right]H_A\left(\alpha,\beta,\beta';\gamma,\beta';x(1-z),\frac{x(1-y)}{2},z\right)$$

$$=(1-z)^{-1}H_{p+1,q}^{m,n}\left[t\left|\begin{matrix}\ldots(\alpha,0)\\\cdots\end{matrix}\right.\right]\sum_{l=0}^{\infty}\frac{(\beta)_l}{(\gamma)_l}(-x)^l P_l^{(-\alpha-l,\alpha-\gamma-l)}(y) \qquad \ldots(2.5)$$

$$|x(1-z)|<r,|(x(y-1))/2|<s,|z|<v,r+s+v=1+sv.$$

Proof of (2.1) To prove (2.1), take L.H.S. of (2.1) and use (1.1) to get

$$H_4\left(\alpha,\beta,\gamma,\delta,\frac{-xy}{(1-x)^2},\frac{-x}{1-x}\right)\sum_{l=0}^{\infty}\frac{x^l}{\ell!}\left\{\frac{1}{2\pi i}\int_L t^s\theta(s)\Gamma(\alpha+l)ds\right\}$$

were $\theta(s)$ is given in (1.1).

Now, changing the order of summation and integration and expressing $\Gamma(\alpha+l)=(\alpha)_l\Gamma(\alpha)$, we obtain

$$H_{p,q+1}^{m+1,n}\left[t\Big|_{(\alpha,0),\ldots}^{\ldots}\right]\left\{(1-x)^{-\alpha}H_4\left(\alpha,\beta,\gamma,\delta,\frac{-xy}{(1-x)^2},\frac{-x}{1-x}\right)\right\}$$

which in view of (1.9) yields R.H.S. of (2.1).

The proofs of the formulas (2.2) to (2.5) would run parallel to what we have obtained above in view of relations (1.10), (1.2), (1.4), (1.8) respectively.

3. Bilinear Generating Relations. In this section we establish the following bilinear relations :

$$\sum_{l=0}^{\infty}\frac{z^l}{l!}H_1(\lambda+\ell,\beta,\gamma,\delta,x,y)H_{p,q+1}^{m+1,n}\left[t\Big|_{(\lambda+\ell,0),\ldots}^{\ldots}\right]$$

$$=(1-z)^{-\lambda}H_1\left(\lambda,\beta,\gamma,\delta,\frac{x}{1-t},y(1-z)\right)H_{p,q+1}^{m+1,n}\left[t\Big|_{(\lambda,0),\ldots}^{\ldots}\right], \qquad \ldots(3.1)$$

$$|x|,u,|y|<v,4uv=(v-1)^2.$$

$$\sum_{l=0}^{\infty}\frac{z^\ell}{\ell!}H_{p,q+1}^{m+1,n}\left[t\Big|_{(\lambda+\ell,0),\ldots}^{\ldots}\right]H_7(\alpha,\lambda+\ell,\gamma,\delta,x,y)$$

$$=(1-z)^{-\lambda}H_{p,q+1}^{m+1,n}\left[t\Big|_{(\lambda,0),\ldots}^{\ldots}\right]H_7\left(\alpha,\lambda,\gamma,\delta,x,\frac{y}{1-z}\right), \qquad \ldots(3.2)$$

$$|x|<u,|y|<v,4u=(v^{-1}-1)^2.$$

$$\sum_{l=0}^{\infty}\frac{z^\ell}{\ell!}H_8(\lambda+\ell,\beta,x,y)H_{p,q+1}^{m+1,n}\left[t\Big|_{(\lambda+\ell,0),\ldots}^{\ldots}\right]$$

$$=(1-z)^{-\lambda}H_{p,q+1}^{m+1,n}\left[t\Big|_{(\lambda,0),\ldots}^{\ldots}\right]H_8\left(\lambda,\beta,\frac{x}{(1-z)^2},y(1-z)\right), |x|<1/4 \qquad \ldots(3.3)$$

$$\sum_{l=0}^{\infty}\frac{t^{\ell}}{\ell!}H_{p,q+1}^{m+1,n}\left[v\left|\begin{matrix}\cdots\\(\lambda+\ell,0),\ldots\end{matrix}\right.\right]G_A(\lambda+\ell,\beta_1,\beta_2;\gamma;x,y,z)$$

$$=(1-t)^{-\lambda}H_{p,q+1}^{m+1,n}\left[v\left|\begin{matrix}\cdots\\(\lambda,0),\ldots\end{matrix}\right.\right]G_A\left(\lambda,\beta_1,\beta_2;\gamma;x(1-t),\frac{y}{1-t},\frac{z}{1-t}\right) \quad \ldots(3.4)$$

$$\sum_{l=0}^{\infty}\frac{t^{l}}{\ell!}G_B(\alpha,\lambda+\ell,\beta_2,\beta_3;\gamma;x,y,z)H_{p,q+1}^{m+1,n}\left[v\left|\begin{matrix}\cdots\\(\lambda+\ell,0),\ldots\end{matrix}\right.\right]$$

$$=(1-t)^{-\lambda}G_B(\alpha,\lambda,\beta_2,\beta_3;\gamma;x/(1-t),y,z)H_{p,q+1}^{m+1,n}\left[v\left|\begin{matrix}\cdots\\(\lambda,0),\ldots\end{matrix}\right.\right] \quad \ldots(3.5)$$

$$\sum_{l=0}^{\infty}\frac{t^{l}}{\ell!}G_C(\alpha,\alpha_1,\lambda+\ell,\beta_1;\gamma;x,y,z)H_{p,q+1}^{m+1,n}\left[v\left|\begin{matrix}\cdots\\(\lambda+\ell,0),\ldots\end{matrix}\right.\right]$$

$$=(1-t)^{-\lambda}H_{p,q+1}^{m+1,n}\left[v\left|\begin{matrix}\cdots\\(\lambda,0),\ldots\end{matrix}\right.\right]G_C\left(\alpha,\alpha_1,\lambda,\beta_1;\gamma;\frac{x}{1-t},y,\frac{z}{1-t}\right) \quad \ldots(3.6)$$

Proof of (3.1) To prove (3.1) take L.H.S. of (3.1) apply (1.1) to get,

$$\sum_{l=0}^{\infty}\frac{z^{\ell}}{\ell!}H_1(\lambda+\ell,\beta,\gamma,\delta,x,y)\left\{\frac{1}{2\pi i}\int_L t^s\theta(s)\Gamma(\lambda+\ell)ds\right\}.$$

Further on changing the order of summation and integration and writing $\Gamma(\lambda+\ell)=\Gamma(\lambda)(\lambda)_l$, we get

$$\frac{1}{2\pi i}\int_L \Gamma(\lambda)\theta(s)t^s ds\left\{\sum_{l=0}^{\infty}\frac{z^{\ell}}{\ell!}(\lambda)_l H_1(\lambda+\ell,\beta,\gamma,\delta,x,y)\right\}$$

which in light of (1.7) provides R.H.S. of (3.1).
Similarly, we can derive (3.2) to (3.6).

4. Special Cases.

(i) In (2.1) taking $\beta=0$ replacing y by $(1-y/2)$ and using result of Rainville [6,p.254], we obtain

$$\sum_{l=0}^{\infty}\frac{x^{l}}{l}H_{p,q+1}^{m+1,n}\left[t\left|\begin{matrix}\cdots\\(\alpha+l,0),\ldots\end{matrix}\right.\right]{}_2F_1\left[\begin{matrix}\alpha/2,(\alpha+1)/2\\\gamma;\end{matrix};\frac{2x(y-1)}{(1-x^2)}\right]$$

$$= H_{p,q+1}^{m+1,n}\left[t\left|\begin{matrix}\cdots\\(\alpha,0),\ldots\end{matrix}\right.\right]\sum_{l=0}^{\infty}\frac{(\alpha)_l}{(\gamma)_l}x^l P_l^{(\gamma-1,\alpha-\gamma)}(y) \qquad ...(4.1)$$

(ii) In (3.1), setting $y=0$, we get a Bilinear generating relation

$$\sum_{l=0}^{\infty}\frac{z^\ell}{l!}H_{p,q+1}^{m+1,n}\left[t\left|\begin{matrix}\cdots\\(\lambda+\ell,0),\ldots\end{matrix}\right.\right]{}_2F_1\left[\begin{matrix}a+\ell,\beta;\\ \delta;\end{matrix}\,x\right]$$

$$=(1-z)^{-\lambda}{}_2F_1\left[\begin{matrix}\lambda,\beta;\\ \delta;\end{matrix}\,\frac{x}{1-z}\right]H_{p,q+1}^{m+1,n}\left[t\left|\begin{matrix}\cdots\\(\lambda,0),\ldots\end{matrix}\right.\right] \qquad ...(4.2)$$

(iii) In (3.2), change y to y/γ and making $\gamma\to\infty$, one obtains the following bilinear generating relation

$$\sum_{l=0}^{\infty}\frac{z^\ell}{\ell!}H_{p,q+1}^{m+1,n}\left[t\left|\begin{matrix}\cdots\\(\lambda+\ell,0),\ldots\end{matrix}\right.\right]H_9(\alpha,\lambda+\ell,\delta,x,y)$$

$$=(1-z)^{-\lambda}H_{p,q+1}^{m+1,n}\left[t\left|\begin{matrix}\cdots\\(\lambda,0),\ldots\end{matrix}\right.\right]H_9\left(\alpha,\lambda,\delta,x,\frac{y}{1-z}\right); \qquad ...(4.3)$$

where H_9 is given in Erdèlyi [2].

(iv) In (3.4), change to (y/β_2) and letting $\beta_2\to\infty$, we obtain bilinear generating relation

$$\sum_{l=0}^{\infty}\frac{t^\ell}{\ell!}H_{p,q+1}^{m+1,n}\left[v\left|\begin{matrix}\cdots\\(\lambda+\ell,0),\ldots\end{matrix}\right.\right]{}_3G_A^{(1)}(\lambda+\ell,\beta_1;\gamma;x,y,z)$$

$$=(1-t)^{-\lambda}H_{p,q+1}^{m+1,n}\left[v\left|\begin{matrix}\cdots\\(\lambda,0),\ldots\end{matrix}\right.\right]{}_3G_A^{(1)}\left(\lambda,\beta_1;\gamma;x(1-t),\frac{y}{1-t},\frac{z}{1-t}\right); \qquad ...(4.4)$$

where ${}_3G_A^{(1)}$ is given by Dhawan [1,p.241].

(v) Again in (3.4), putting $x=x/\beta_1$, $z=z/\beta_1$ and making $\beta_1\to\infty$ we find bilinear generating relation

$$\sum_{l=0}^{\infty}\frac{t^\ell}{\ell!}H_{p,q+1}^{m+1,n}\left[v\left|\begin{matrix}\cdots\\(\lambda+\ell,0),\ldots\end{matrix}\right.\right]{}_3G_A^{(2)}(\lambda+\ell,\beta_2;\gamma;x,y,z)$$

$$=(1-t)^{-\lambda}H_{p,q+1}^{m+1,n}\left[v\left|\begin{matrix}\cdots\\(\lambda,0),\ldots\end{matrix}\right.\right]{}_3G_A^{(2)}\left(\lambda,\beta_2;\gamma;x(1-t),\frac{y}{1-t},\frac{z}{1-t}\right); \qquad ...(4.5)$$

where ${}_3G_A^{(2)}$ is given in [1, p.241].

REFERENCES

[1] G.K. Dhawan, Hypergeometric functions of three variables, *Proc. Nat. Acad. Sci. India.* **(A)40,I,** (1970), 43-48.

[2] A. Erdélyi, A. et al., *Higher Transcendental Functions.* **Vol. I,** McGraw Hill, New York, 1953.

[3] C. Fox, The *G* and *H* functions as symmetrical Fourier kernels. *Trans. Amer. Math. Soc.*, **98**, (1961), 395-429.

[4] P.R. Khandekar, On a generalisation of Rice's Polynomials-1. *Proc. Nat. Acad. Sci. India, Sect. A,* **34**, Part II (1964), 157-162.

[5] R.C. Pandey, On certain transformations of hypergeometric functions of three variables, *J. Math. and Mech.,* **12(1)** (1963), 113-118.

[6] E.D. Rainville, *Special Functions,* The Macmillan Co., New York, 1960; *Reprinted Chelsea Publ. Co. Bronx, New York,* 1971.

[7] F. Singh and B.M. Shrivastava. Some new generating relations for generalised Horn functions, *Indian J. Pure Appl. Math.,* **7**, No.11 (1976).

[8] F. Singh and B.M. Shrivastava, On some new generating relations. *Ranchi Univ. Math. J.,* **5** (1974).

[9] B.M.L. Shrivastava. *A Study of Special Functions of One and Two Variables with Some Applications*, Ph.D. Thesis, A.P.S. University, Rewa, (1975).

[10] B.M.L. Shrivastava, On some new results involving double and triple hypergeometric functions, *Kyungpook Math. J.*, **16** No.2 (1976).

[11] B.M.L. Shrivastava, Generating functions for Jacobi, Laguerre and generalized Rice's polynomials. *Vijnana Parishad Anushandhan Patrika,* **17** No. 4 (1974), 297-301.

[12] H.M. Srivastava, K.C. Gupta and S.P. Goyal, *The H-Function of One and Two Variables with Applications.* South Asian Publishers, New Delhi, 1982.

[13] H.M. Srivastava, Hypergeometric functions of three variables. *Ganita,* **15** (1964), 97-108.