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A NOTE ON NEW GENERATING RELATIONS FOR FUNCTIONS OF SEVERAL VARIABLES

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ABSTRACT. In this paper we have derived generating relations for functions of several variables by using the operator $T_k = x(k + xD)$ and the operational relations involving this operator. Some recent results of Srivastava and Panda [7] have been conveniently obtained by this method as well as some hitherto unknown results established.

Introduction. Lauricella's function of several variables is defined as follows

$$(1.1)\quad F_D^{(r)}[(\alpha; m_i):(\beta_i; \phi_i); (\gamma; \Psi_i); x_1,\ldots,x_r] = \sum_{k_1,\ldots,k_r=0}^{\infty} \frac{(\alpha)_{\varepsilon m_i k_i}(\beta_1)k_1\phi_1 \cdots (\beta_r)_{k_r\phi_r}}{(\gamma)_{\varepsilon k_i \Psi_i}} \cdot \frac{x_1^{k_1}\cdots x_r^{k_r}}{k_1!\cdots k_r!},$$

where the parameters α, β, γ are arbitrary complex numbers, the coefficients m_i, ϕ_i, Ψ_i are real and positive and for the convergence of multiple series

$$(1.2)\qquad 1 + \Psi_i - m_i - \phi_i \geqslant 0, \qquad i = 1,2,\ldots,r,$$

the equality holds only if $|x_1|$, $|x_2|,\ldots,|x_r|$ are constrained appropriately. In particular if, $m_i = m$, $\Psi_i = \Psi$, $i = 1,2,\ldots,r$, then the equality in (1.2) will hold when either

$$(1.3)\qquad m > \Psi \quad \text{and} \quad \sum_{i=1}^{r}\left(\frac{|x_i|}{G_i}\right)^{1/(m-\Psi)} < 1$$

or

$$(1.4)\qquad m \leqslant \Psi \quad \text{and} \quad \max_{1\leqslant i\leqslant r}\left\{\frac{|x_i|}{G_i}\right\} < 1,$$

where

$$(1.5)\qquad G_i = m^{-m}\phi_i^{-\phi_i}\Psi^{\Psi}, \qquad i = 1,2,\ldots,r.$$

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In this paper we have found new generating relations for Lauricella's function and some related function of several variables, viz.

$$(1.6)\quad \sum_{n_1,\ldots,n_r=0}^{\infty} \frac{(\lambda_1)_{2n_1}\cdots(\lambda_r)_{2n_r}t_1^{n_1}\cdots t_r^{n_r}}{(\lambda_1)_{n_1}\cdots(\lambda_r)_{n_r}n_1!\cdots n_r!}$$
$$\cdot F_D^{(r)}[(\lambda;m_i):(-n;m_i);(\gamma;\Psi_i);x_1,\ldots,x_r]$$
$$= \prod_{i=1}^{r}\left\{(1-4t_i)^{-1/2}\left[\frac{2}{1+(1-4t_i)^{1/2}}\right]^{\lambda_i-1}\right\}$$
$$\cdot F_D^{(r)}[(\lambda;m_i):(1-\lambda_i-2n_i;m_i);(\gamma;\Psi_i);$$
$$x_1\left(\frac{2t_1}{1+(1-4t_1)^{1/2}}\right)^{m_1},\ldots,x_r\left(\frac{2t_r}{1+(1-4t_r)^{1/2}}\right)^{m_r}\Bigg].$$

Recently Srivastava and Panda [7] considered the functions

$$(1.7)\qquad f[z_1,\ldots,z_r] = \sum_{k_1,\ldots,k_r=0}^{\infty} C(k_1,\ldots,k_r)\frac{z_1^{k_1}}{k_1!}\cdots\frac{z_r^{k_r}}{k_r!},$$

where the coefficients $C(k_1,\ldots,k_r)$, $k_i \geqslant 0$, $i = 1,2,\ldots,r$, are arbitrary constants real or complex.

$$(1.8)\qquad \Delta_{n_1,\ldots,n_r:q_1,\ldots,q_r}^{(\alpha_1,\ldots,\alpha_r:\beta_1,\ldots,\beta_r)}(z_1,\ldots,z_r) = \sum_{k_1=0}^{[n_1/q_1]}\cdots\sum_{k_r=0}^{[n_r/q_r]} C(k_1,\ldots,k_r)$$
$$\cdot\prod_{i=1}^{r}\left\{\frac{(-n_i)_{q_ik_i}}{(1+\alpha_i+\beta_in_i)_{q_ik_i}}\frac{z_i^{k_i}}{k_i!}\right\}$$

where α_i and β_i are parameters independent of $n_1,\ldots,n_r$ and q_i are arbitrary positive integers, $i = 1,\ldots,r$ and

$$(1.9)\quad S_{n_1,\ldots,n_r:q_1,\ldots,q_r}^{(\alpha_1,\ldots,\alpha_r:\beta_1,\ldots,\beta_r)}[\lambda_1,\ldots,\lambda_r:z_1,\ldots,z_r] = \sum_{k_1=0}^{[n_1/q_1]}\cdots\sum_{k_r=0}^{[n_r/q_r]} C(k_1,\ldots,k_r)$$
$$\cdot\prod_{i=1}^{r}\left\{\frac{(-n_i)_{q_ik_i}(1+\alpha_i+(\beta_i+1)n_i)_{\lambda_ik_i}}{(1+\alpha_i+\beta_in_i)_{(\lambda_i+q_i)k_i}}\frac{z_i^{k_i}}{k_i!}\right\}$$

where α_i, β_i and λ_i, $i = 1,2,\ldots,r$, are complex parameters independent of $n_1,\ldots,n_r$ and $q_1,\ldots,q_r$ are arbitrary positive integers and derived the generating relation for them.

Besides these Srivastava [5, 6], Sharma and Abiodun [1] and Carlitz and Srivastava [10] derived generating relations for (1.7) and the G function and obtained generating functions for Lauricella's function of several variables. Shukla [2] using the operator $T_k = x(k + xD)$ and the operational relations involving these operators derived the results of Srivastava [6], Sharma and Abiodun [1] and Carlitz and Srivastava [10] and established some hitherto unknown results.

In this paper we propose to derive the results of Srivastava and Panda [7] and other results by making use of operator formulas (2.1), (3.1), (3.4), (3.7) and (3.9).

In §2 we obtain generating relations for functions defined by (1.8) and (1.9) and in §3 we derive various generating functions for Lauricella's function of several variables.

2. Generating relations for functions of several variables. In this section we shall use the Mittal [4] operational generating formula

$$\sum_{n=0}^{\infty} \frac{1}{n!} T^{n}_{a+1+(m-1)n}\{f(x)\} = \frac{(1+\nu)^{a+1}}{1-(m-1)\nu} f[x(1+\nu)], \tag{2.1}$$

where $\nu = x(1+\nu)^m$, m being constant and $f(x)$ admits a formal power series in x and $T_k \equiv x(k + xD)$, $D = d/dx$.

Assuming that the operator $T_{1,k}$ is the operator T_k operating on t_1 alone and similarly $T_{r,k}$ the operator on t_r alone and replacing a by $a_1 = \alpha_1, \ldots, a_r = \alpha_r$, m by $m_1 = \beta_1 + 1, \ldots, m_r = \beta_r + 1$, n by $n_1, n_2, \ldots, n_r$ respectively and putting

$$f(x) \equiv f\left[x_1\left(-y_1^{-\beta_1} t_1^{\beta_1+1}\right)^{m_1}, \ldots, x_r\left(-y_r^{-\beta_r} t_r^{\beta_r+1}\right)^{m_r}\right]$$

in (2.1) r times, we easily get

$$\begin{aligned} &\sum_{n_1,\ldots,n_r=0}^{\infty} \binom{\alpha_1 + (\beta_1+1)n_1}{n_1} \cdots \binom{\alpha_r + (\beta_r+1)n_r}{n_r} t_1^{n_1} t_2^{n_2} \cdots t_r^{n_r} \\ &\quad \cdot \sum_{k_1,\ldots,k_r=0}^{N} C(k_1,\ldots,k_r) \prod_{i=1}^{r} \left\{ \frac{(-n_i)_{m_i k_i}}{(1+\alpha_i+\beta_i n_i)_{m_i k_i}} \frac{x_i^{k_i} y_i^{-\beta_i m_i} t_i^{(1+\beta_i)m_i}}{k_i!} \right\} \\ &= \frac{(1+\nu_1)^{\alpha_1+1} \cdots (1+\nu_r)^{\alpha_r+1}}{(1-\beta_1\nu_1)\cdots(1-\beta_1\nu_r)} f\left[x_1\left[-y_1^{-m_1\beta_1}\left\{t_1^{\beta_1+1}(1+\nu_1)^{\beta_1+1}\right\}^{m_1}\right], \ldots, \right. \\ &\qquad \left. x_r\left[-y^{-m_r\beta_r}\left\{t_r^{\beta_r+1}(1+\nu_r)^{\beta_r+1}\right\}^{m_r}\right]\right], \end{aligned} \tag{2.2}$$

where $\nu_i = t_i(1+\nu_i)^{\beta_i+1}$, $i = 1, 2, \ldots, r$, and $N = \min(n_1, n_2, \ldots, n_r)$. Now putting $y_i = t_i$, $i = 1, 2, \ldots, r$, in (2.2) we get

$$\begin{aligned} &\sum_{n_1,\ldots,n_r=0}^{\infty} \binom{\alpha_1 + (\beta_1+1)n_1}{n_1} \cdots \binom{\alpha_r + (\beta_r+1)n_r}{n_r} \\ &\qquad \cdot \Delta^{(\alpha_1,\ldots,\alpha_r:\, \beta_1,\ldots,\beta_r)}_{n_1,\ldots,n_r:\, m_1,\ldots,m_r}(x_1,\ldots,x_r) t_1^{n_1} \cdots t_r^{n_r} \\ &\qquad = \frac{(1+\nu_1)^{\alpha_1+1} \cdots (1+\nu_r)^{\alpha_r+1}}{(1-\beta_1\nu_1)\cdots(1-\beta_r\nu_r)} f\left[x_1(-\nu_1)^{m_1}, \ldots, x_r(-\nu_r)^{m_r}\right], \end{aligned} \tag{2.3}$$

where the function Δ is given by (1.8), which is due to Srivastava and Panda [7, Theorem 2]. Further with the similar assumptions on operator T_k, a and m as in the derivation of (2.3), but taking

$$f(x) \equiv f\left[x_1(-1)^{m_1} y_1^{-\beta_1 m_1 - \lambda_1} t_1^{(1+\beta_1)m_1+\lambda_1}, \ldots, x_r(-1)^{m_r} y_r^{-\beta_r m_r - \lambda_r} \cdot t_r^{(1+\beta_r)m_r+\lambda_r}\right]$$

in (2.1) and using it r times, we similarly have

$$(2.4)\qquad \sum_{n_1,\dots,n_r=0}^{\infty} \binom{\alpha_1+(\beta_1+1)n_1}{n_1}\cdots\binom{\alpha_r+(\beta_r+1)n_r}{n_r}$$
$$\cdot S^{(\alpha_1,\dots,\alpha_r;\,\beta_1,\dots,\beta_r)}_{n_1,\dots,n_r:\,m_1,\dots,m_r}[\lambda_1,\dots,\lambda_r : x_1,\dots,x_r]\,t_1^{n_1}\cdots t_r^{n_r}$$
$$= \prod_{i=1}^{r}\left\{\frac{(1+\nu_i)^{\alpha_i+1}}{(1-\beta_1\nu_i)}\right\} f\left[x_1(-\nu_1)^{m_1}(1+\nu_1)^{\lambda_1},\dots,x_r(-\nu_r)^{m_r}(1+\nu_r)^{\lambda_r}\right],$$

where $\nu_i = t_i(1+\nu_i)^{\beta_i+1}$, $i = 1,2,\dots,r$, and the function S is given by (1.9). This is also due to Srivastava and Panda [7, Theorem 2.1].

3. Lauricella's function of several variables. We now make use of the Mittal [3] operational formula

$$(3.1)\qquad \sum_{n=0}^{\infty}\frac{1}{n!}T_{a+1}^{n}\{f(x)\} = (1-x)^{-a-1} f\left[\frac{x}{1-x}\right],$$

where $f(x)$ admits a formal power series in x. Replacing a by $a_1 = \lambda_1 - 1,\dots,a_r = \lambda_r - 1$, n by $n_1,\dots,n_r$ and assuming that $T_{i,k}$ is the operator T_k operating on t_i alone for $i = 1,2,\dots,r$ respectively and putting

$$f(x) \equiv F_D^{(r)}\left[(\lambda;\, m_i) : (\beta_i;\, \phi_i);\, (\gamma;\, \Psi_i);\, (-t_1)^{m_1}x_1,\dots,x_r(-t_r)^{m_r}\right]$$

in (3.1) and using it r times, we get

(3.2)

$$\sum_{n_1,\dots,n_r=0}^{\infty}\frac{(\lambda_1)_{n_1}\cdots(\lambda_r)_{n_r}t_1^{n_1}\cdots t_r^{n_r}}{n_1!\cdots n_r!}$$
$$\cdot\sum_{k_1,\dots,k_r=0}^{N}\frac{(\lambda)_{\varepsilon m_i k_i}(-n_1)_{m_1k_1}\cdots(-n_r)_{m_rk_r}(\beta_1)_{k_1\phi_1}\cdots(\beta_r)_{k_r\phi_r}}{(\gamma)_{\varepsilon\Psi_i k_i}(\lambda_1)_{m_1k_1}\cdots(\lambda_r)_{m_rk_r}}\cdot\frac{x_1^{k_1}\cdots x_r^{k_r}}{k_1!\cdots k_r!}$$
$$= \prod_{i=1}^{r}\left\{(1-t_i)^{\lambda_i}\right\}F_D^{(r)}\left[(\lambda;\, m_i) : (\beta_i;\, \phi_i);\, (\gamma;\, \Psi_i);\right.$$
$$\left. x_1\left(\frac{t_1}{t_1-1}\right)^{m_1},\dots,x_r\left(\frac{t_r}{t_r-1}\right)^{m_r}\right].$$

Taking $\beta_r = \lambda_r$ and $\phi_r = m_r$ in (3.2) we have the generating relation

(3.3)

$$\sum_{n_1,\dots,n_r=0}^{\infty}\frac{(\lambda_1)_{n_1}\cdots(\lambda_r)_{n_r}t_1^{n_1}\cdots t_r^{n_r}}{n_1!\cdots n_r!}F_D^{(r)}[(\lambda;\, m_1) : (-n_i;\, m_1);\, (\gamma;\, \Psi_i); x_1,\dots,x_r]$$
$$= \prod_{i=1}^{r}\left\{(1-t_i)^{\lambda_i}\right\}F_D^{(r)}\left[(\lambda;\, m_i);\, (\lambda_i,\, m_i);\, (\gamma;\, \Psi_i);\right.$$
$$\left. x_1\left(\frac{t_1}{t_1-1}\right)^{m_1},\dots,x_r\left(\frac{t_r}{t_r-1}\right)^{m_r}\right].$$

Again by making use of the Mittal [3] operational formula

$$\sum_{n=0}^{\infty} \frac{1}{n!} T_{a+n}^{n}\{f(x)\} = (1-4x)^{-1/2}\left[\frac{2}{1+(1-4x)^{1/2}}\right]^{a-1} \cdot f\left[\frac{2x}{1+(1-4x)^{1/2}}\right], \tag{3.4}$$

replacing a by $a_1 = \lambda_1, \ldots, a_r = \lambda_r$, n by $n_1, \ldots, n_r$ and assuming that $T_{i,k}$ is the operator T_k operating on t_i alone, $i = 1, 2, \ldots, r$, respectively and taking

$$f(x) \equiv F_D^{(r)}[(\lambda; m_i); (\beta_i; \phi_i); (\gamma; \Psi_i); x_1 t_1^{m_1}, \ldots, x_r t_r^{m_r}]$$

in (3.4) and using it r times, we have the generating relation
(3.5)

$$\sum_{n_1,\ldots,n_r=0}^{\infty} \frac{(\lambda_1)_{2n_1} \cdots (\lambda_r)_{2n_r} t_1^{n_1} \cdots t_r^{n_r}}{(\lambda_1)_{n_1} \cdots (\lambda_r)_{n_r} n_1! \cdots n_r!} \cdot \sum_{k_1,\ldots,k_r=0}^{N} \frac{(\lambda)_{\varepsilon m_i k_i} (-n_1)_{m_1 k_1} \cdots (-n_r)_{m_r k_r} (\beta_1)_{k_1 \phi_1} \cdots (\beta_r)_{k_r \phi_r}}{(\gamma)_{\varepsilon k_i \Psi_i} (1-\lambda_1-2n_1)_{m_1 k_1} \cdots (1-\lambda_r-2n_r)_{m_r k_r}} \cdot \frac{x_1^{k_1} \cdots x_r^{k_r}}{k_1! \cdots k_r!}$$
$$= \prod_{i=1}^{r} \left\{(1-4t_i)^{-1/2}\left[\frac{2}{1+(1-4t_i)^{1/2}}\right]^{\lambda_i - 1}\right\} \cdot F_D^{(r)}\left[(\lambda; m_i): (\beta_i; \phi_i); (\gamma; \Psi_i); x_1\left(\frac{2t_1}{1+(1-4t_1)^{1/2}}\right)^{m_1}, \ldots, x_r\left(\frac{2t_r}{1+(1-4t_r)^{1/2}}\right)^{m_r}\right].$$

Putting $\phi_r = m_r$ and $\beta_r = 1 - \lambda_r - 2n_r$ in equation (3.5), we get
(3.6)

$$\sum_{n_1,\ldots,n_r=0}^{\infty} \frac{(\lambda_1)_{2n_1} \cdots (\lambda_r)_{2n_r} t_1^{n_1} \cdots t_r^{n_r}}{(\lambda_1)_{n_1} \cdots (\lambda_r)_{n_r} n_1! \cdots n_r!} F_D^{(r)}[(\lambda; m_i): (-n_i; m_i); (\gamma; \Psi_i); x_1, \ldots, x_r]$$
$$= \prod_{i=1}^{r} \left\{(1-4t_i)^{-1/2}\left[\frac{2}{1+(1-4t_i)^{1/2}}\right]^{\lambda_i - 1}\right\} \cdot F_D^{(r)}\left[(\lambda; m_i): (1-\lambda_i-2n_i; m_i); (\gamma; \Psi_i); x_1\left(\frac{2t_1}{1+(1-4t_1)^{1/2}}\right)^{m_1}, \ldots, x_r\left(\frac{2t_r}{1+(1-4t_r)^{1/2}}\right)^{m_r}\right].$$

Again, making use of the Mittal [3] operational formula

$$\sum_{n=0}^{\infty} \frac{1}{n!} T_{a-n}^{n}\{f(x)\} = (1+x)^{a-1} f[x(1+x)], \tag{3.7}$$

and proceeding as above, we get the generating relation

$$\begin{aligned}(3.8)\quad & \sum_{n_1,\ldots,n_r=0}^{\infty} (-1)^{n_1+\cdots+n_r} \prod_{i=1}^{r} \frac{(1-\lambda_i)_{n_i} t_i^{n_i}}{n_i!} \\ & \cdot F_{1:0,\ldots,0}^{1:2,\ldots,2}\left[\begin{matrix}(\lambda; m_i):(-n; m_i), (\lambda_i; m_i); x_1,\ldots,x_r \\ (\gamma; \Psi_i)\end{matrix}\right] \\ & = \prod_{i=1}^{r} (1+t_i)^{\lambda_i - 1} F_D^{(r)}\big[(\lambda; m_i):(\lambda_i - n_i; 2m_i); (\gamma; \Psi_i); \\ & \qquad x_1\big(-t_1(1+t_1)^{m_1}\big),\ldots,x_r\big(-t_r(1+t_r)^{m_r}\big)\big].\end{aligned}$$

Next, using the Mittal [3] operational formula

(3.9)

$$\sum_{n=0}^{\infty} \frac{1}{n!} T_{a-2n}^{n}\{f(x)\} = (1+4x)^{-1/2}\left[\frac{2}{1+(1+4x)^{1/2}}\right]^{-a} \cdot f\left[\frac{x+(1+4x)^{1/2}}{2}\right],$$

replacing a by $a_1 = \lambda_1,\ldots,a_r = \lambda_r$, n by $n_1,\ldots,n_r$ and assuming that $T_{i,k}$ is the operator T_k operating on t_i alone, $i = 1,2,\ldots,r$, respectively and putting

$$f(x) \equiv F_D^{(r)}\left[(\lambda; m_i):(\beta_i; \phi_i); (\gamma; \Psi_i); x_1\left(\frac{27}{4}t_1\right)^{m_1},\ldots,\left(\frac{27}{4}t_r\right)^{m_r}\right]$$

in (3.9) and using (3.9) r-times we get the following generating relation:

$$\begin{aligned}(3.10)\quad & \sum_{n_1,\ldots,n_r=0}^{\infty} \prod_{i=1}^{r} \frac{(1-\lambda_i)_{2n_i} t_i^{n_i}}{n_i!\,(1-\lambda_i)_{n_i}} \\ & \cdot \sum_{k_1,\ldots,k_r=0}^{N} \frac{(\lambda)_{\varepsilon m_i k_i} (\beta_1)_{k_1\phi_1} \cdots (\beta_r)_{k_r\phi_r}}{(\gamma)_{\varepsilon m_i k_i}} \cdot \frac{x_1^{k_1}\cdots x_r^{k_r}}{k_1!\cdots k_r!} \\ & \cdot \prod_{i=1}^{r}\left[\frac{((\lambda-n_i)/2)_{m_i k_i}((\lambda-n_i+1)/2)_{m_i k_i}(-n_i)_{m_i k_i}}{((\lambda-2n_i)/3)_{m_i k_i}((\lambda-2n_i+1)/3)_{m_i k_i}((\lambda-2n_i+2)/3)_{m_i k_i}}\right] \\ & = \prod_{i=1}^{r}\left\{(1+4t_i)^{-1/2}\left[\frac{2}{1+(1+4t_i)^{1/2}}\right]^{-\lambda_i}\right\} \\ & \cdot F_D^{(r)}\left[(\lambda; m_i):(\beta_i; \phi_i); (\gamma; \Psi_i); x_1\left[\frac{27}{4}t_1\{1+(1+4t_1)^{1/2}\}^{m_1}\right],\ldots,\right. \\ & \qquad \left. x_r\left[\frac{27}{4}t_r\{1+(1+4t_r)^{1/2}\}^{m_r}\right]\right],\end{aligned}$$

which is a generalization of a result due to Shukla [**2**]. Finally replacing a by $a_1 = \lambda_1 - 1, \ldots, a_r = \lambda_r - 1$, n by $n_1, \ldots, n_r$ and assuming that $T_{i,k}$ is the operator T_k operating on t_i alone, $i = 1, 2, \ldots, r$ respectively and putting

$$f(x) \equiv F_D^{(r)}\left[(\lambda; m_i) : (\beta_i; \phi_i); (\gamma; \Psi_i); x_1\left[\frac{(2-m)^{2-m}}{(1-m)^{1-m}} t_1\right]^{m_1}, \ldots, x_r\left[\frac{(2-m)^{2-m}}{(1-m)^{1-m}} t_r\right]^{m_r}\right]$$

in (2.1) and using it r-times we get the generating relation

$$\begin{aligned}
(3.11) \quad & \sum_{n_1, \ldots, n_r = 0}^{\infty} (-1)^{n_1 + \cdots + n_r} \prod_{i=1}^{r} \frac{(\lambda_i)_{mn_i} t_i^{n_i}}{n_i!\,(\lambda_i)_{(m-1)n_i}} \\
& \cdot \sum_{k_1, \ldots, k_r = 0}^{N} \frac{(\lambda)_{\varepsilon m_i k_i} (\beta_1)_{k_1 \phi_1} \cdots (\beta_r)_{k_r \phi_r} x_1^{k_1} \cdots x_r^{k_r}}{(\gamma)_{\varepsilon k_i \Psi_i} k_1! \cdots k_r!} \\
& \cdot \prod_{i=1}^{r} \left[\frac{(-n_i)_{m_i k_i} ((\lambda + mn_i)/(1-m))_{m_i k_i} \cdots}{((\lambda + (m-1)n_i)/(2-m))_{m_i k_i} \cdots} \frac{((\lambda + mn_i - m)/(1-m))_{m_i k_i}}{((\lambda + (m-1)n_i + 1 - m)/(2-m))_{m_i k_i}}\right] \\
& = \prod_{i=1}^{r} \frac{(1+\nu_i)^{\lambda_i}}{(1-(m-1)\nu_i)} F_D^{(r)}\left[(\lambda; m_i) : (\beta_i; \phi_i); (\gamma; \Psi_i); x_1\left[\frac{(2-m)^{2-m}}{(1-m)^{1-m}} t_1 (1+\nu_1)\right]^{m_1}, \ldots, x_r\left[\frac{(2-m)^{2-m}}{(1-m)^{1-m}} t_r (1+\nu_r)\right]^{m_r}\right],
\end{aligned}$$

where $\nu_i = t_i(1+\nu_i)^m$, $i = 1, 2, \ldots, r$, which is again a generalization of a result due to Shukla [**2**].

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