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EFFECT OF PLANT GROWTH REGULATOR APPLICATION AT DIFFERENT GROWTH STAGES ON THE ECONOMICAL YIELD POTENTIAL OF COARSE RICE (*Oryza Sativa* L.)

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ABSTRACT

The study was conducted to find out the growth behaviour of transplanted coarse rice (IR-6) as influenced by plant growth regulator (NAA) under the agro climatic conditions of Dera Ismail Khan, Pakistan, during 2004 and 2005 using Randomized Complete Block Design with split plot arrangements. Main plot consisted of three critical growth stages of paddy rice, namely S1 (tillering) S2 (panicle initiation) and S3 (grain formation stage), while sub plot contained four levels of 0, 60, 90 and 120 ml ha^{-1} of plant growth regulator (Naphthalene Acetic Acid). The data was recorded on plant height (cm) at maturity, number of panicle (m^{-2}), number of spikelets $panicle^{-1}$, 1000-grain weight (g) and paddy yield (Mg ha^{-1}). The effect of plant growth regulator levels, growth stages of paddy rice and interactions between them were found highly significant (LSD, $p \leq 0.01$) in term of enhancement in paddy yield and yield components. The application of plant growth regulator @ 90 ml ha^{-1} at the stage of panicle initiation proved most beneficial in terms of attaining 130.4 cm and 130 cm as maximum plant height, 324.5 m^2 and 328 m^2 as highest number of panicles, 164.3 and 168.5 as maximum number of spikelets $panical^{-1}$, 78.5% and 80.5% as maximum normal kernels, 20.76g and 21.02g as higher 1000-grain weight, 7.65 Mg ha^{-1} as economical paddy yield during 2004 and 2005 respectively.

Key words: Rice, Stages, Plant Growth Regulator, Naphthalene Acetic Acid.

INTRODUCTION

Rice (*Oryza Sativa* L.) is one of the most important cereal crops of the world in terms of food, area and production (Niamatullah *et al*., 2010). Pakistan is basically an agriculture country but agriculture in this country suffers from low production due to low yield per unit area (Awan *et al*., 2011). To meet the increased demand for food grain of rapidly growing population, there are many yield boosting agronomic techniques like application of certain plant growth regulators which needs due attention. Although plant growth regulators have been used in agriculture for as long as crop cultivation, their impact up to now has been relatively little detected and their application is limited to some specific objectives for example quality and quantity improvement (Pandey *et al*., 2001). Plant growth regulators are synthesized indigenously by plants, however, several studies demonstrated that plants can respond to exogenous application of these chemicals. An exogenous application of plant growth regulators affects the endogenous hormonal pattern of the plant, either by supplementation of sub-optimal levels or by interaction with their synthesis, translocation or inactivation of existing hormone levels (Arshad and Frankenberger, 1993).

Naphthalene Acitic Acid, a wide-broad, somatotrophin-like growth regulator in plants. It produces significant effects in promoting development of pointed ends for the root system, resulting in more, straighter and thicker roots. NAA can increase fruit setting ratio, prevent fruit dropping, promote flower sex ratio. Hao and Ichii (1999) isolated a dominant auxin-resistant mutant in rice (Oryza sativa L. ssp.japonica cv. Oochikara) in a screen for 2, 4-dichlorophenoxyacetic acid (2, 4-D) resistance and named it Lrt1 (lateral rootless). Lrt1 also exhibited resistance to synthetic auxin 1-naphthaleneacetic acid (NAA) and natural auxins indole-3-acetic acid (IAA) and indole-3-butyric acid (IBA) (Chhun *et al*., 2003).

The present study was conducted to investigate the effect of exogenously applied plant growth regulator (NAA) with different levels at three critical growth stages of coarse rice to enhance their productivity.

MATERIALS AND METHODS

The research project on the effect of plant growth regulator (NAA) on the yield and yield potential of coarse rice was conducted at the Postgraduate Agriculture Research Farm, Gomal University, Dera Ismail Khan, NWFP, Pakistan, during rice growing seasons in 2004 and 2005 respectively. The nature of soil

was clay having pH range of 7.9 to 8.1. The experiment was laid out in Randomized Complete Block Design with split plot arrangements, replicated 4 times. The plant growth stages were allocated to main plots and levels of the growth regulator to sub plots. The net plot size was 3 x 5 m^{-2}. Naphthalene Acetic Acid 4.5% in sodium salt was applied with the help of hand pump sprayer. Four different levels of plant growth regulator (NAA) i.e. 0, 60, 90 and 120 ml ha-1 were applied at the time of tillering stage (S1), panicle initiation stage (S2) and grain formation stage (S3). Whereas recommended doses of NP were applied at the rate of 120 kg N ha^{-1} in the form of urea and 100 kg P ha^{-1} in the form of SSP (Maqsood *et al*., 2001). The full dose of phosphorus was applied at the time of transplanting, while nitrogen was applied in two split doses, half at the time of transplanting and remaining half at the time of panicle initiation. Seeds of IR-6 variety were selected at specific gravity of 1.13 in 0.5% Sodium Chloride solution. The seeds that sink in salt water were selected for sowing and other light floating and un-viable seeds were discarded. After rinsing the salt water, the seed was kept immersed in water for 24 hours and then under moist gunny bags for 36 hours. The sprouted seed was sown at well prepared seed bed. The 35 days old seedling, free of pests and disease were transplanted in the plots using row to row and plant to plant spacing of 20 x 20 cm on 15th June each year. All other agronomic practices (i.e seedbed preparation, plant protection measures, application of fertilizers and irrigation etc) were kept uniform during the crop growth. The data were recorded on plant height (cm) by selecting ten plants at random from each plot at maturity. Their height was measured from the soil surface to the tip of panicle / flag leaf with the help of a meter rod and average height was calculated. Total numbers of panicles m^{-2} in each plot were counted at harvest from fixed places earmarked for recording tillers. Spikelets per panicle were averaged from 10 randomly selected panicles taken from each plot. The panicles were collected from the same places earmarked for recording tillers. The normal kernels % was calculated from 10 randomly selected panicles from each plot at harvest. After averaging (6^{th} October as harvesting date) the total spikelets per panicle, the normal kernels percentage was calculated as;

Normal Kernel percentage = Normal kernels/Total number of kernels x 100

From the dry seed lot of each plot, samples of 1000-grain weight (g) were taken and weighed. Paddy yield was recorded from each plot. After harvesting, the clean rough rice was bulked and weighed at 14% moisture contents and expressed in Mg ha^{-1} as;

$$\text{Paddy yield (Mg ha}^{-1}) = \frac{\text{Plot yield (kg)} \times 10000}{\text{Plot size (m}^2) \times 1000}$$

All the collected data were tabulated and analyzed statistically using analysis of variance technique and subsequently Least Significance Test (LSD at 1%) for comparing the treatment means, by MStat Computer software (Steel *et al.*,1981997).

RESULTS AND DISCUSSION

Plant Height (cm): Plant height (cm) at maturity in Table 1 indicated that plant growth regulator (PGR) at different growth stages affected this trait significantly during both the cropping seasons. The application of PGR at growth stage S2 (panicle initiation stage) showed maximum plant height of 130.4 and 130.0 cm during 2004 and 2005, respectively.

As far as the effect of PGR on plant height of rice is concerned, it was observed that various plant growth regulator levels significantly affected the plant height at P = 0.01. During both the years of experimentation, the tallest plants (132.7 and 135.4 cm) were recorded in the treatment where 90 ml ha^{-1} of PGR was applied followed by 60 ml application, while during both years of study the smallest plants were observed in control.

The interaction of growth stages and plant growth regulator levels was also highly significant during both years of study at the treatment G2 (90 ml ha^{-1}) and S2 (panicle initiation stage) was at top with 140 and 142 cm plant height during 2004 and 2005 respectively. It seams to be due to intact cells elongation. Watanabe and Saigusa, (2004) stated that plant height was significantly increased by the application of 50 ppm ethephon, 100ppm GA3 alone or in combination over that of control.

Number of Panicles (m^{-2}): The data given in table 2 revealed that various growth stages, differed significantly from each other during both the cropping seasons regarding number of panicles (m^{-2}). It revealed that treatment S2 (panicle initiation stage) shows maximum number of panicles (324.5 m^{-2}) during 2004 and (328.0 m^{-2}) during 2005. As far as the effect of plant growth regulator (NAA) levels on number of panicles (m^{-2}) is concerned, it was observed that various plant growth levels significantly affected number of panicles during both the year of study. The highest number of 330.7 and 333.0 m^{-2} panicles were recorded in the treatment having 90 ml ha^{-1} level of plant growth regulator, followed by 60 ml ha^{-1} producing 319.3 and 322.3 panicles m^{-2} during 2004 and 2005 respectively.

The interaction of rice growth stages and plant growth regulator levels was also highly significant during both the years of study. The treatment S2 X G2 (panicle initiation stage with 90ml ha^{-1}) produced maximum number of panicles (340 and 342 m^{-2}) during both years of experimentation, while the lowest number of 305 and 308 m^{-2} panicles were recorded in treatment S3 (grain

formation stage) with highest dose (120 ml ha^{-1}) of plant growth regulator applied during both years of study.

Number of Spikelets Panicle^{-1}: The results shown in table 1 revealed that rice growth stages in relation to plant growth regulator (NAA) application, affected significantly the number of spikelets panicle^{-1}. The data on number of spikelets panicle^{-1} indicated that various growth stages of rice differed significantly from each other during both the cropping seasons. It revealed that the S2 (panicle initiation stage) produced maximum number of 164.3 and 168.50 spikelets panicle^{-1} during 2004 and 2005, respectively. The effect of plant growth regulator levels on number of spikelets per panicle were found significant during both the years of experimentation. The maximum number of 171.3 and 176.0 spikelets panicle^{-1} were recorded in the treatment having 90 ml ha^{-1} of plant growth regulator followed by 60 ml ha^{-1} during both the years of study.

The interaction of rice growth stages and plant growth regulator levels was also highly significant during both the years of experiment. The stage S2 X G2 (panicle initiation stage) with 90 ml ha^{-1} of plant growth regulator level gave maximum number of 182 and 187 spikelets panicle^{-1} during subsequent years of study, while the lowest number of spikelets panicle^{-1} were recorded in plots with high dose (120 ml ha^{-1}) of plant growth regulator at S3 (grain formation stage) and in control plots. Misra and Sahu (1957) reported that number of spikelets and grains favorably influenced by NAA @ 500ppm ha^{-1}.

Table 1: Plant height (cm), number of panicles (m^{-2}) and number of spikelets panicle^{-1} as affected by plant growth regulator levels applied at three growth stages of transplanted coarse rice

	Plant Height (cm)		Number of Panicle (m^{-2})		Number of Spikelets Panicle^{-1}	
	2004	**2005**	**2004**	**2005**	**2004**	**2005**
S1 (Tillering stage)	123.5 b	124.8 b	317.8 b	320.0 b	156.5 b	161.5 b
S2 (Panicle initiation stage)	130.4 a	130.0 a	324.5 a	328.0 a	164.3 a	168.5 a
S3 (Grain formation stage)	118.3 c	121.1 c	311.5 c	314.5 c	151.3 c	156.3 c
LSD (0.01)	2.823	3.581	6.074	2.118	3.426	4.208
G0 (0ml ha^{-1})	115.7 d	116.0 d	308.7 c	312.0 c	146.0 d	151.3 d
G1 (60ml ha^{-1})	127.3 b	127.7 b	319.3 b	322.3 b	160.0 b	164.0 b
G2 (90ml ha^{-1})	132.7 a	135.4 a	330.7 a	333.0 a	171.3 a	176.0 a
G3 (120ml ha^{-1})	120.5 c	122.0 c	313.0 c	316.0 c	151.0 c	157.3 c
LSD (0.01)	3.850	4.067	4.734	4.777	5.170	4.215
S1X G0 (S1 X 0ml ha^{-1})	114.0*	117.0*	309.0*	312.0*	145.0*	151.0*
S1X G1 (S1 X 60ml ha^{-1})	127.0	127.0	319.0	321.0	161.0	165.0
S1X G2 (S1 X 90ml ha^{-1})	133.0	135.0	330.0	332.0	170.0	174.0
S1X G3 (S1 X 120ml ha^{-1})	120.0	120.0	313.0	315.0	150.0	156.0
S2X G0 (S2 X 0ml ha^{-1})	117.0	116.0	310.0	314.0	147.0	150.0
S2X G1 (S2 X 60ml ha^{-1})	135.0	134.0	327.0	331.0	168.0	171.0
S2X G2 (S2 X 90ml ha^{-1})	140.0	142.0	340.0	342.0	182.0	187.0
S2X G3 (S2 X 120ml ha^{-1})	129.0	128.0	321.0	325.0	160.0	166.0
S3X G0 (S3 X 0ml ha^{-1})	116.0	115.0	307.0	310.0	146.0	153.0
S3X G1 (S3 X 60ml ha^{-1})	120.0	122.0	312.0	315.0	153.0	156.0
S3X G2 (S3 X 90ml ha^{-1})	125.0	129.3	322.0	325.0	162.0	167.0
S3X G3 (S3 X 120ml ha^{-1})	112.0	118.0	305.0	308.0	144.0	150.0

Means followed by different letter(s) are significantly different at 1% level of probability using LSD test.

***Normal Kernels Percentage*:** The data presented in table 2 indicated that rice growth stages in response to plant growth regulator application, significantly affected the normal kernel percentage during both the cropping seasons. The crop growth stage S2 (panicle initiation stage) produced maximum normal kernels of 78.5 and 80.5% during 2004 and 2005 respectively, while lowest normal kernels 67.25 and 65.75% were recorded in S3 (grain formation stage).The plant growth regulator (NAA) levels significantly affected the normal kernels during both the planting seasons. The highest normal kernels (81.25 and 80.33%) were recoded in treatment G2 (90 ml ha^{-1}) during both the years. While the lowest normal kernels of 70.0 and 70.33% were noted in the treatment where higher dose of 120 ml ha^{-1} was applied.

The interaction of rice growth stages and plant growth regulator levels was also highly significant during both the years of study. The treatment S2 X G2 (panicle initiation stage with 90 ml ha^{-1} plant growth regulator level) showed more normal kernels of 88.0 and 90%

during 2004 and 2005 respectively, while the lesser normal kernels percentage was recorded in plots of S1 x G0 during both the years of study. Similar results are given by Ismal *et al*. (2005); they stated that GA3 @75 g ha^{-1} in two splits increased the number of normal kernels.

Gibberellic Acid (GA) and Indole Acetic Acid (IAA) application at panicle initiation stage increase normal kernels may be due to the fact that leaves in treated plots remain functional for a larger period of time. The second reason might be the longer functionality of the vascular bundles in different parts of the panicle, which have resulted in an efficient translocation of photosynthesis (Awan *et al*., 1999).

1000-Grain Weight (g): Data in table 2 indicated that 1000-grain weight was highly significant at different growth stages during both the years of experimentation in response of plant growth regulator (NAA). Highest 1000-grain weight of 20.76g and 21.02g was recorded during 2004 and 2005 respectively. Plant growth regulator levels affected the 1000-grain weight during both the years of study. The highest 1000-grain weight was recorded in the treatment with G2 (90ml ha^{-1} NAA) producing 21.12 and 21.40g during 2004 and 2005, respectively, while the lowest 1000-grain weight was noted in the control plots and with higher dose (120 ml ha^{-1}) of plant growth regulator. Gurmani *et al*. (2006) given the similar results. The interaction of rice growth stages and plant growth regulator levels were highly significant during both the years of study and the treatment S2 x G2 produced maximum 1000-grain weight during both the years of study.

Paddy Yield (Mg ha^{-1}): Table 2 shows that paddy yield was significantly affected for different growth stages of rice and levels of NAA application during both the years. The crop growth stage S2 (panicle initiation stage) showed economical paddy yield of 7.65 and 7.925 Mg ha^{-1} during 2004 and 2005, while the lowest paddy yield of 6.331 and 6.550 Mg ha^{-1} was recorded in treatment S3 (grain formation stage) during both the cropping seasons respectively. The plant growth regulator levels significantly affected the paddy yield during both the cropping seasons. The economical paddy yield of 8.117 and 8.40 Mg ha^{-1} was recorded in the treatment G2 (90 ml ha^{-1}) during 2004 and 2005, respectively, while the lesser paddy yield of 6.167 and 6.367 Mg ha^{-1} was recorded in control plots and with higher dose (120 ml ha^{-1}) applied at S3 during 2004 and 2005 respectively.

Table 2: Normal kernels %, 1000-grain weight (g) and paddy yield (t ha^{-1}) as affected by plant growth regulator levels applied at three growth stages of transplanted coarse rice

	Normal kernels %		1000-grain weight (g)		Paddy Yield (t ha^{-1})	
	2004	2005	2004	2005	2004	2005
S1 (Tillering stage)	73.44 b	73.25 b	19.29 b	19.58 b	6.93 ab	7.200 b
S2 (Panicle initiation stage)	78.50 a	80.5 a	20.76 a	21.02 a	7.650 a	7.925 a
S3 (Grain formation stage)	67.25 c	65.75 c	18.68 c	18.81 c	6.331 b	6.550 c
LSD (0.01)	3.712	3.896	0.248	0.189	0.3523	0.3866
G0 (0 ml ha^{-1})	64.67 d	66.00 c	18.12 d	18.31 d	6.167 c	6.367 c
G1 (60 ml ha^{-1})	76.33 b	73.00 b	20.10 b	20.33 b	7.167 b	7.333 b
G2 (90 ml ha^{-1})	81.25 a	80.33 a	21.12 a	21.40 a	8.117 a	8.400 a
G3 (120 ml ha^{-1})	70.00 c	70.33 b	18.97 c	19.17 c	6.475 c	6.800 c
LSD (0.01)	4.061	4.235	0.15	0.20	0.3523	0.4410
S1X G0 (S1 X 0 ml ha^{-1})	63.00*	66.00*	18.20*	18.30*	6.200*	6.400*
S1X G1 (S1 X 60 ml ha^{-1})	77.00	74.00	19.70	20.00	7.000	7.200
S1X G2 (S1 X 90 ml ha^{-1})	81.75	80.00	20.60	21.00	8.150	8.400
S1X G3 (S1 X 120 ml ha^{-1})	72.00	73.00	18.67	19.00	6.500	6.800
S2X G0 (S2 X 0 ml ha^{-1})	62.00	65.00	18.00	18.40	6.300	6.500
S2X G1 (S2 X 60 ml ha^{-1})	82.00	85.00	21.80	22.00	8.000	8.400
S2X G2 (S2 X 90 ml ha^{-1})	88.00	90.00	23.00	23.20	9.000	9.200
S2X G3 (S2 X 120 ml ha^{-1})	78.00	82.00	20.25	20.50	7.300	7.600
S3X G0 (S3 X 0 ml ha^{-1})	65.00	67.00	18.15	18.23	6.000	6.200
S3X G1 (S3 X 60 ml ha^{-1})	70.00	60.00	18.81	19.00	6.500	6.400
S3X G2 (S3 X 90 ml ha^{-1})	74.00	71.00	19.76	20.00	7.200	7.600
S3X G3 (S3 X 120 ml ha^{-1})	60.00	56.00	18.00	18.00	5.625	6.000

Means followed by different letter(s) are significantly different at 1% level of probability using LSD test.

The interaction of crop growth stages and plants growth regulator levels was also highly significant during both the years of experimentation with respect to paddy yield. The treatment S2 x G2 produced economical paddy yield

of 9.00 and 9.20 Mg ha^{-1} during both the years of study, while the lowest paddy yield was recorded in S3 x G3 and in control plots during 2004 and 2005 respectively. Gurmani *et al*. (2006), they stated that ABA, BA and CCC plant growth regulators increased grain yield of rice. The finding are also similar with Pandey *et al*. (2001), whom reported that IAA @ 50 ppm produced significantly maximum grain yield per plant, 1000-grain weight and yield kg ha^{-1}. These were significantly different form all other treatments. The enhance yield under IAA may be due to increase in panicle length, number of panicle. The other possible reasons for the best yield recorded in IAA treatment would be the capability of this treatment in efficiency channelizing the assimilated to the grains. Alam *et al*. (2002), observed that 20 ppm concentration of NAA showed better results in enhancing grain yields of wheat cultivars.

Conclusion: Form the present experiment, it can be concluded that various levels of plant growth regulator significantly affected the various growth stages of transplanted coarse rice. The application of plant growth regulator (NAA) level of 90 ml ha^{-1} at panicle initiation stage had significant beneficial effects on the yield attributes of coarse rice and increased the grain yield. It is, therefore concluded that plant growth regulator (NAA) level of 90 ml ha^{-1} is the best combination for economical yield of rice.

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