Vol. 21 · June 2015
Print ISSN 2012-3981 • Online ISSN 2244-0445
DOI: http://dx.doi.org/10.7719/jpair.v21i1.324
Journal Impact: H Index = 2 from Publish or Perish

JPAIR Multidisciplinary Research is produced
by PAIR, an ISO 9001:2008 QMS certified
by AJA Registrars, Inc.

Effect of Different Levels of Paclobutrazol on the Yield of Asha and Farmers' Variety of Peanut

MARY GRACE B. GATAN
http://orcid.org 0000-0002-6083-0060
mbgatan.mgbg@gmail.com
Pampanga State Agricultural University
Magalang, Pampanga

VIRGILIO DM. GONZALES
http://orcid.org 0000-0002-7476-4703
virgon3000@gmail.com
Pampanga State Agricultural University
Magalang, Pampanga

ABSTRACT

Peanut (*Arachis hypogaea*) is commonly grown during the dry season and most farmers used the native variety. Growth retardants such as paclobutrazol (PBZ) was found to increase yield of some important crops. A study was conducted to determine the effect of different levels of paclobutrazol on the peanut yield of Asha and Farmers' variety during the wet season. The experimental area was laid out using Randomized Complete Block Design (RCBD) factorial. Treatments were replicated thrice. Data were analyzed by Analysis of Variance (ANOVA) and the Honest Significant Difference (HSD) test was used to compare treatment means. The increasing level of PBZ increased the number of pods of Asha by 29.97% while the most number of seeds was obtained from farmers' variety. Applied PBZ Asha at 150mg/L recorded the highest shelling percentage that is 16.19% higher when compared to the untreated. Paclobutrazol application significantly increased seed yield of Asha and farmers' variety by 43.34% and 20.86% at 150mg/L and 75mg/L, respectively. The increase in yield was due to the observed reduction in plant height and stem growth which possibly enhanced assimilate partitioning to pods. Asha applied with PBZ at 150mg/L obtained the highest seed yield of 4.2 tons/ha.

Keywords — Agriculture, yield, peanut, paclobutrazol, experimental design, Pampanga, Philippines

INTRODUCTION

About 95% of the peanut areas in the country are planted with the native low yielding variety. In the country, farmers are concern in finding means on how to increase peanut production. Paclobutrazol, a plant growth retardant is usually applied to some important crops to reduce unwanted shoot growth without lowering plant productivity. Plant growth regulators play a vital role in many physiological processes associated with growth and development of plants (P. S. Thakur & A. Thakur, 1993). Paclobutrazol was discovered in 1976 and is a member of the triazoles, which are the most highly active class of growth retardants. Paclobutrazol is commonly known as PP333™, cultar™,paclo™, and Bonzi. It is effective on a wide range of plants species, including several bulbous and woody plants, which are not proved sensitive to other retardants (Purohit, 1985).

Paclobutrazol is a xylem-mobile, and, therefore, effective retardation relies primarily on uptake of the chemical via the roots. Because triazoles chemicals can be transported in the xylem, they may be absorbed by the leaves, but cannot be moved out of the leaves to other parts of the plant. The most consistent effect of paclobutrazol on growth retardation is that it can induce additional effects such as an increase in ear or grain number or modification in canopy structure. Paclobutrazol have been reported to reduce the sterol levels of plant tissues. The functional role of sterols in membranes and the regulatory properties of the brassinosteroids may contribute to the spectrum of effects that these growth retardants can exert under certain conditions. Because of this, paclobutrazol is very active at low rates it is applied at the rate of 2 to 90 ppm. Paclobutrazol is a post-emergence growth regulator and is applied anytime after the emergence of target plants. Effects may not be noticeable for up to eighteen months. Growth retardants such as paclobutrazol are sometimes called anti gibberellins because they inhibit gibberellin biosynthesis which reduces gibberellin levels and causes a decrease in shoot growth (Hartmann, Kester & Davies Jr. 1990).

Paclobutrazol reduce plant growth by inhibiting the microsomal oxidation of kaurene, kaurenol, and kaurenal, which is catalyzed by kaurene oxidase, a cytochrome P-450 oxidase (Davis, Steffens, Sankhla, 1988;Izumi, Kamiya, Sakurai, Oshio & Takahashi, 1985). In addition to blocking gibberellin biosynthesis, paclobutrazol have been shown to inhibit sterol biosynthesis (Haughan, Burden, Lenton & Goad, 1989), reduce ABA (Wang, Sun, Ji & Faust, 1987), ethylene (Sauerbrey, Grossman & Jung, 1988) and indole – 3–acetic acid (Law & Hamilton, 1989); an increase cytokinin content (Izumi et al., 1988).

The effects of triazoles particularly the paclobutrazol on hormonal changes, photosynthetic rate, enzyme activities and yield components was reported by Zhou and Ye

(1996). Paclobutrazol is an inhibitor of endogenous gibberellin synthesis by preventing the oxidation of ent-kaurene to ent-kaurenol, a precursor of gibberellic acid. Paclobutrazol applied with 100-200 ppm at the early pod filling of the peanut stage showed the greatest increase in pod and seed yields compared to that of untreated or with 400 ppm paclobutrazol. The number of pods m^{-2}pod reached 370g/m^2 that is due to the gain in podding rates during the early flowering stage resulting in the alteration of the distribution of assimilates from the foliage to the pods. In addition, photosynthetic potentials, such as chlorophyll contents, efficiencies of photosystem II and CO2 assimilation rates, were improved by the paclobutrazol treatment (Senoo & Isoda, 2003).

In 2011, XiuMei et al., stated that the paclobutrazol treatment reduced pod number, productivity per plant and yield of peanuts relative to the control. According to Chen et al., (2010), paclobutrazol also reduced the peanut plant height and lateral branch while increasing the number of branches and number of pod per plant, rate of filled pod and oil content of seed. In addition, reported that peanut applied with paclobutrazol resulted in the reduction of stem length. Paclobutrazol at 150 mg/L applied at blossoming stage inhibited the growth of the main stems and branches. However, the number of pods per plant and percentage of filled pods were increased resulting to increase in yield (Ming-hui, 2009).

The application of paclobutrazol at blooming stage of peanut inhibited the height of a plant and promoted the pod filling percentage, hence increased the yield and income. The optimum amount of paclobutrazol was 500g/m^{-2}(Liang, Senlin, Zhizhong & Zheng Chen, 1995). Zheng (2008) reported that 15%

paclobutrazol could effectively inhibit the growth of peanut plants and promote more pods and mature pods leading to high yield. The 15% paclobutrazol effectively controlled the growth of above-ground part of peanut plants and led to the highest yield.

The spray concentration of 50 mg/kg of paclobutrazol can produce high pod yield (4518 kg/m^{-2}), compared with 3756 kg/m^{-2} in CK (Tao, Zhang, Chen & Zhang, 2000). Soaking the seeds with different concentrations of paclobutrazol delayed germination of seeds, decreased germination rate and plant height of peanut. At harvest, the number of pods, the rate of plump pod and the yield of peanut were higher in the paclobutrazol treatment than that in the control. The highest peanut yield was found in 150mg/L paclobutrazol, which reached 3806.3 kg/m^{-2} and 12.6% higher than the control (Runmei, Li & Chen, 2004).

Moreover, Qiankai, Huashou, Jianzhang and Shuiyuan (2010) reported that paclobutrazol solutions applied at a rate of 75-100mg/L at blossoming stage, significantly inhibited the main stems and branches while the number of pods per plant and filled pods increased. The frequent paclobutrazol application could decrease the number of pods per plant, the rate of filled pods and yield, and it could also increase the number of young and the unfilled pods (Hailing, 2011).

Low yield is one of the problems encountered by farmers during wet season planting because the upper portion of peanut is prioritized at the expense of pod formation. One possible solution to this problem is through the use of paclobutrazol. The PBZ is believed to improve yield thereby increasing farmers production and profit. In addition, research particularly on the effect of various levels of PBZ on different varieties of peanut is limited. Thus, this study was conducted.

OBJECTIVES OF THE STUDY

The study was conducted to determine the effect of different levels of paclobutrazol to peanut varieties particularly on yield. Specifically, it aimed to determine the days to flower and maturity; pod number per plant; seed number/pod; weight of 100 seed; shelling percentage and seed yield/hectare.

MATERIALS AND METHODS

The study was conducted during the wet season planting of peanut, May to October 2013 in Pampanga, Philippines using Asha and Farmers' variety of peanut. The following are the characteristics of the varieties used.

Asha is a variety developed by ICRISAT. The seed yield averaged 3.0-3.5t/ha and is harvested 121-122 days after planting. Its plant height ranged from 55.9-74.15cm with a shelling percentage of 71.9% during wet season and 74.2% in the dry season. The weight of 100 seeds is 71.9-74.2g. It is large seeded variety with pink seed color.

Farmers' Variety was developed by BPI and is also known locally as "Kalbo". Days to flower is from 23-20 days after planting, and its plant height ranged from 41-64cm. The seed yield averaged 1.0-1.5 t/ha. It is harvested 80-90 days after planting depending on the season. It is small seeded variety, having three seeds per pod with red seed color.

The experimental area was laid out following the procedure in three-factor Factorial Randomized Complete Block Design (RCBD) factor-factorial. Each treatment combination was replicated three times. The following were the two factors involved in the study.

Factor A (Peanut Variety)

T_1 –Asha

T_2 –Farmers variety

Factor B (Levels of Paclobutrazol, PBZ)

L_1 – Control (pure water)

L_2 – 75mg PBZ per Liter of water

L_3 – 150mg PBZ per Liter of water

L_4 – 225mg PBZ per Liter of water

A total area of 342m^2 was used in conducting the experiment having eight treatment combinations including the border plants. Each plot measures 2m in width and 5m in length comprising of four rows spaced 0.5 m apart. An alleyway of one meter between replications was provided for ease in placing stakes, plot tags, data gathering, weeding, and harvesting. Border Ridge was provided to prevent seepage in case rains occur after paclobutrazol application.

The area was thoroughly prepared by plowing two times alternately followed by two harrowing to obtain fine tilth that is essential to achieve good germination. After the final harrowing, the field was furrowed at a distance of 50cm.

Soil samples were collected before the conduct of the experiment as the basis of fertilizer application. The soil samples were pulverized; air dried and mixed thoroughly to make a composite soil sample, and this was brought to the Soils Laboratory at San Fernando, Pampanga for soil analysis. Based from the result, the type of soil is sandy loam.

Calcium nitrate at the rate of 0.645g/hill that is equivalent to 12.9g/m^2 was applied basally prior to planting. In addition to Calcium nitrate, organic fertilizer was also applied at a rate of 50g/m^2. Both organic fertilizer and Calcium nitrate were applied uniformly along the rows and was covered with 2-3 cm layer of soil.

Peanut seeds were inoculated with Rhizobium at the rate of 100g/50kg of seeds. Inoculation was done by coating the seeds with inoculant using water at least two hours before planting. Two seeds were planted per hill. Thinning was done ten days after planting. Ten plants were maintained per linear meter. The distance between hills is 10cm and 50cm between furrows.

Plants were watered immediately after sowing to enhance gernmination. Watering was provided three times throughout the experimental period so that soil will not be too dry and prevent wilting of the plants. Hilling-up was done only during the flowering stage to cover the shallow pegs. Weeding was also done manually and regularly until the flowering stage.

Paclobutrazol was applied following the different levels specified in the treatment. The solution was sprayed to the plants during the peak of flowering that is about 30-40 days after planting for the Asha variety and 25-30 days after planting for the farmers' variety.

Harvesting of peanut depended on the maturity indices of each variety used. Peanut were harvested when the leaves show signs of maturity by the change of color from green to slightly yellow and more than 75% of the pods per plant have ridges and when the inner side of the shell have dark venations. The Asha and Farmers' variety were harvested 120DAP and 90DAP, respectively. Harvesting was done manually. Sun drying was done immediately after harvesting. Peanuts were exposed to sunlight for five days depending on the weather condition.

Data Collection and Computation

1. Days to flower. This was counted and recorded as the number of days from emergence to that day when 50% of the plants in a row have produced their first open flower.
2. Days to maturity. This was counted and recorded as the number of days from emergence, and at least 75% of the pods show signs of maturity (dark brown pods with deep ridges) for peanut.

3. Number of pods per plant. This was determined by the average number of pods per plant at harvest using the ten randomly sample plants.
4. Number of seeds per pod. This was counted as the number of seeds obtained from 10 randomly selected mature pods from the 10 sample plants.
5. Weight of 100 seeds. This was done by selecting at random 100 seeds from each plot, and it will be recorded the weight in grams.
6. Shelling percentage. This was obtained by weighing 100-gram unshelled pod samples from each plot. Shell the sample pods and weight the cleaned seeds. Shelling percentage is the weight of shelled beans from the 100-gram pod sample.
7. Seed yield/hectare. The clean seed yield from 1m^2 of each plot was weighed and recorded, and the computed final seed yield from one m^2 served as a basis for computing the seed yield in tons/ha.

Statistical Analysis

All data were subjected to statistical analysis to Analysis of Variance (ANOVA). Honest Significant Difference (HSD) test was used to compare treatment means.

RESULTS AND DISCUSSION

Days to Flower

As shown in Table 1, a noticeable difference in days to flower was observed. Farmer's variety produced flowers approximately five days earlier compared to Asha. Early flowering is one of the distinct characteristics of an early maturing variety such as the farmers' variety. Neither paclobutrazol (PBZ) levels nor the method of paclobutrazol application influenced the number of days to flower.

Figure 1a. Farmers' variety during flowering stage

Figure 1b. Asha during flowering stage

Table 1. Days to flower of asha and farmers' variety of peanut in relation to levels of paclobutrazol application.

Variety	Mean
T_1 – Asha	28.38[b]
T_2 – Farmers'variety	23.58[a]

*Means within the column followed by a common letter is not significantly different at 5% HSD level.

Days to Maturity

Significant variations were noted among treatments. Asha exhibited the longest day to mature. Its maturity is longer (120DAP) when compared to farmers' variety (90DAP) simply because its pod filling period is longer, and it is large seeded. Late maturing is one of the distinct characteristics of Asha. There is no effect of PBZ levels on days to maturity across varieties.

Number of Pods per Plant at Harvest

Paclobutrazol application significantly affected the number of pods per plant of the two varieties of peanut (Table 2a). Asha evidently produced 46% more pods compared to farmers' variety.

Table 2a. Number of pods per plant of asha and farmers' variety of peanut in relation to the levels of paclobutrazol application.

Variety	**Mean**
T_1– Asha	29.16[b]
T_2– Farmers' variety	19.75[a]

*Means within the column followed by a common letter is not significantly different at 5% HSD level.

Paclobutrazol treatments increased the number of pods per plant in two varieties of peanut. (Table 2b). At least 75mg/L of PBZ is needed to increase the number of pods per plant. In other studies, application of paclobutrazol effectively inhibit peanut growth but can produce more pods resulting in high yield (Zheng, 2008). This increased in pod number is due to PBZ application that could shorten basal internodes. The shortened basal internodes should result to early emerging pegs proximal to ground penetration for pod formation.

Table 2b. Number of pods per plant applied with different levels of paclobutrazol across types of peanut application.

Levels of Paclobutrazol	**Mean**
L_1– Control (Pure water)	20.82[b]
L_2– 75mg/L of water	26.17[a]
L_3– 150mg/L of water	27.06[a]
L_4– 225mg/L of water	23.76[ab]

*Means within the column followed by a common letter is not significantly different at 5% HSD level.

Table 2c. Number of pods per plant at harvest as affected by different levels ofpaclobutrazol across varieties of peanut.

Levels of Paclobutrazol	Mean**
L_1– Control	**20.82[B]**
L_2– 75mg/L of water	**26.17[A]**
L_3– 150mg/L of water	**27.05[A]**
L_4– 225mg/L of water	**23.76[AB]**

* Means having the same letter are not significantly different at 5% HSD level.

Number of Seeds per Pod at Harvest

There was varietal variation in the number of seeds per pod across levels of PBZ application (Table 3). Asha is two seeded per pod while farmers' variety is approximately three seeded. The findings confirm with the agronomic characteristics of the varieties used that Asha is two-seeded while farmers' variety is three seeded.

Table 3. Number of seeds per pod at harvest of asha and farmers' variety of peanut in relation to levels paclobutrazol application

Variety	Mean
T_1– Asha	2.00[b]
T_2 – Farmers' variety	2.80[a]

*Means within the column followed by a common letter is not significantly different at 5% HSD level.

Weight of 100 Seeds

Asha produced the heavier weight, more than two folds than the farmers' variety (Table 4). This can be possibly attributed to the longer pod filling period of Asha resulting to larger seed. On the other hand, farmers' variety obtained the lightest seed mass due to its small size and shorter filling period, as farmers' variety is an early maturing genotype (90 days vs. 120 days in Asha).

Table 4. Weight of 100 seeds at harvest of asha and farmers'variety of peanut in relation to levels of paclobutrazol application

Variety	Mean
T_1– Asha	80.08[a]
T_2 – Farmers' variety	35.42[b]

*Means within the column followed by a common letter is not significantly different at 5% HSD level.

Shelling Percentage

The shelling percentage of Asha and farmers' variety showed significant difference (Table 5a). Asha obtained shelling percentage heavier than the farmers' variety.

Table 5a. Shelling percentage of asha and farmer's variety of peanut in relation to levels and methods of paclobutrazol application.

Variety	Mean
T_1– Asha	77.21[a]
T_2– Farmers' variety	72.59[b]

*Means within the column followed by a common letter is not significantly different at 5% HSD level.

Table 5b showed an interaction effect among varieties of peanut and paclobutrazol application. Asha applied at 150mg/L of PBZ obtained the highest shelling percentage. Regardless of PBZ levels, farmers' variety attained low shelling percentage and were comparable with the untreated.

Table 5b. Shelling percentage of peanut as affected by varieties of peanut of paclobutrazol application.

Variety of Peanut	Level of Paclobutrazol	Mean
Asha	L_1- Control	74.50[B]
	L_2- 75mg/L	76.33[AB]
	L_3- 150mg/L	80.00[A]
	L_4- 225mg/L	78.00[AB]
Farmers' Variety	L_1- Control	73.00[B]
	L_2- 75mg/L	73.33[B]
	L_3- 150mg/L	72.67[B]
	L_4- 225mg/L	71.33[B]

*Variety and level means having the same letter (A-B) are not significantly different at 5% HSD level.

Computed Seed Yield per Hectare

Levels of paclobutrazol significantly increased the seed yield of the two varieties of peanut (Table 6). Application of PBZ in Asha at any rate considerably increased yield but highest when applied at the rate of 150mg/L. In farmer's variety, it appears that seed yield tended to increase yield at 75mg/L. It is believed that peanut applied with paclobutrazol altered dry matter distribution towards the growth seed resulting in increased yield. The photosynthetic potentials such as chlorophyll contents, efficiencies of photosystem II and CO_2 assimilation rates were improved through PBZ application at the proper concentration (Senoo & Isoda, 2003).

Table 6. Seed yield (ton/ha) of asha and farmer's variety type of peanut in relation to levels of paclobutrazol.

Level of Paclobutrazol	Variety of Peanut		Mean**
	Asha	Farmer's variety	
L_1– Control	2.93^{BC}	2.78^{BC}	**2.86^{b}**
L_2– 75mg/L of water	3.62^{AB}	3.36^{ABC}	**3.49^{a}**
L_3– 150mg/L of water	4.20^{A}	2.65^{C}	**3.42^{a}**
L_4– 225mg/L of water	3.52^{AB}	2.61^{C}	**3.07^{ab}**

*Level means having the same letter (A-C) are not significantly different at 5% level under HSD.
**Variety and level means with the same letter (a-b) are not significantly different at 5% level

CONCLUSION

The increasing level of PBZ increased number of pods of Asha. The most number of seeds was obtained from farmers' variety. Asha applied with PBZ at 150mg/L recorded the highest shelling percentage. Paclobutrazol application significantly increased seed yield of Asha and farmers' variety at 150mg/L.

TRANSLATIONAL RESEARCH

At present, the country is 60-70% import-dependent on peanut and this is because of the limited supply and availability of improved peanut varieties that known to be high yielding, large seeded and resistant to major fungal diseases. Through this study, the production yield of peanut is enhanced through appropriate levels of PBZ application. As a result, this will lead to a sufficient and continuous supply of peanut in the country that will also provide additional income to farmers and peanut growers.

ACKNOWLEDGMENTS

The authors expressed their sincerest thanks to the Pampanga State Agricultural University and Agricultural Training Institute – Region III, Philippines for providing financial assistance to this research endeavor.

LITERATURE CITED

Chen, H. L., Huang, J. T., Li, Q. H., Qiu, G. Q., Li, S. P., & Xie, Z. Q. (2010). Effect of Paclobutrazol on Development and Quality of Valencia Type Peanut [J]. *Journal of Peanut Science*, *4*, 018.

Davis, T. D., Steffens, G. L., & Sankhla, N. (1988). Triazole plant growth regulators. *Horticultural Reviews, Volume 10*, 63-105.

Hailing, C. (2011). Effect of Paclobutrazol More Sprayed on Growth and Development, Yield of Valencia Type Peanut. *Anhui Agricultural Science Bulletin*, *19*, 031.

Hartmann, H. T., D.E. Kester and F.T. Davies Jr. 1990. Plant Propagation Principles and Practices. 5th edition, Prentice Hall, Eaglewood Cliffs. New Jersey.

Haughan, P. A., Burden, R. S., Lenton, J. R., & Goad, L. J. (1989). Inhibition of celery cell growth and sterol biosynthesis by the enantiomers of paclobutrazol. *Phytochemistry*, *28*(3), 781-787.

Izumi, K., Kamiya, Y., Sakurai, A., Oshio, H., & Takahashi, N. (1985). Studies of sites of action of a new plant growth retardant (E)-1-(4-chlorophenyl)-4, 4-dimethyl-2-(1, 2, 4-triazol-1-yl)-1-penten-3-ol (S-3307) and comparative effects of its stereoisomers in a cell-free system from Cucurbita maxima. *Plant and cell physiology*, *26*(5), 821-827.

Izumi, K. Y., S. Nakagawa, M. Kobayashi, H. Oshio, A. Sakurai and N. Takahashi. 1988. Levels of IAA, cytokines, ABA and ethylene in rice plants as affected by a gibberellins biosynthesis inhibitor, uniconazole-P. Plant Cell Physiology. 29:97.

Law, D. M., & Hamilton, R. H. (1989). Reduction in the free indole-3-acetic acid levels in Alaska pea toy the gibberellin biosynthesis inhibitor uniconazol. *Physiologia Plantarum*, *76*(4), 535-538.

Liang, H. D. Senlin, W. Zhizhong and W. Zheng Chen. 1995. The Effect of P333 on Growth and Yield of Peanut. Journal of Shenyang Agricultural University.

Ming-hui, Y. U. (2009). 1, YU Xin-chun 1, SHEN Guan-wang 1, HU Jian-tao 1, PENG Bao-hong 2, YAN De-yuan 1 (1. Research Institute of Agricultural Sciences in Xinyang, Xinyang, Henan 464000, China; 2. Meteorological Bureau in Xinyang, Xinyang, Henan 464000, China); Application Effect of Paclobutrazol on Peanut [J]. *Tianjin Agricultural Sciences*, *1*.

Qiankai, T., Huashou, L., Jianzhang, C., & Shuiyuan, L. (2010). Effects of Paclobutrazol on Agronomical Characteristics and Its Yields of Peanut. *Chinese Agricultural Science Bulletin*, *8*, 032.

Runmei, P. E. I. (2004). 1, LI Yangrui~ 2, CHEN Nianping~ 3 (1The Editorial Office of Journal, Guangxi University, Nanning 530005, China; 2Guangxi Academy of Agricultural Sciences, Nanning 530007, China; 3Agricultural College, Guangxi University, Nanning 530005, China); Effects of paclobutrazol on germination and growth of peanut [J]. *Journal of Guangxi Agricultural and Biological Science*, *2*.

Purohit, S. S. (Ed.). (1985). *Hormonal regulation of plant growth and development* (Vol. 1). Springer Science & Business Media.

Sauerbrey, E., Grossmann, K., & Jung, J. (1988). Ethylene production by sunflower cell suspensions effects of plant growth retardants. *Plant physiology*,*87*(2), 510-513.

Senoo, S and A. Isoda. 2003. Volume 6. No. 1. Pp.90-94.Crop Science Society of Japan. Tokyo, Japan.

Tao, S. X., Zhang, J. C., Chen, D. X., & Zhang, L. F. (2000). Study on Effect of Peanut Seed Treated with Paclobutrazol and Its Spray Concentration on peanut Intercropped [J]. *PEANUT SCIENCE AND TECHNOLOGY*, *2*.

Thakur, P. S., & Thakur, A. (1993). Influence of triacontanol and mixtalol during plant moisture stress in Lycopersicon esculentum cultivars. *Plant physiology and biochemistry*, *31*(3), 433-439.

Wang, S. Y., Sun, T., Ji, Z. L., & Faust, M. (1987). Effect of paclobutrazol on water stress-induced abscisic acid in apple seedling leaves. *Plant physiology*,*84*(4), 1051-1054.

XiuMei, T., Chao, L., RuiChun, Z., Jing, J., ZhuQiang, H., LiangQiong, H., ... & RongHua, T. (2011). Comparative studies on the chemical regulation of peanuts by paclobutrazol, mepiquat chloride and chlorocholine chloride. *Journal of Southern Agriculture*, *42*(6), 603-605.

Zheng, M. 2008. Application of three plant growth regulators to peanut production.Subtropical Agriculture Research.

Zhou, W., & Ye, Q. (1996). Physiological and yield effects of uniconazole on winter rape (Brassica napus L.). *Journal of Plant Growth Regulation*, *15*(2), 69-73.