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Research Article

The utilization efficiency of fertilizer N and K to improve yellow Manado Corn production and quality in Tomohon city

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Abstract

Corn (*Zea mays* L) is cereal crop that has strategic and economic value and can be developed as a major source of carbohydrates, vitamins and minerals as well as animal feed and industrial raw materials. The main purpose of the research is to improve the growth and production as well as the quality of the local yellow Manado corn, thus the research is conducted: (1) To obtain the optimum dose of fertilizer N and K which can improve the growth, yield and nutritional quality of maize; (2) To get a proper application time of urea to be done and tillage on growth, yield and nutritional quality of maize. Application of urea and KCl increase the growth and yield of corn. Urea-dose combination of 300 kg ha^{-1} + KCl 100 kg ha^{-1} results in the highest growth and yield of corn. Urea-dose of 300 kg ha-1 results in the highest dry shelled yield weight per hectare of of 3.24 t ha^{-1}, a KCl-dose of 100 kg ha^{-1} results in dry shelled weight of 2.89 t ha^{-1}. Urea-dose combination of 300 kg ha^{-1} + KCl 100 kg ha^{-1} results in the highest carotenoid and sugar content, respectively: starch of 65.10%, sugar and carotene content of 5.37% 2.03 mg/g. The combination of the use of 300 kg ha-1 urea and 100 kg ha-1 KCL, as well as cultivated and nurtured land as much as 2 times at 15 and 45 days after planting and at planting 3 times, 30 DAT and 45 DAT results the highest growth, yield, nutritional quality. Therefore, the related studies to the regulation of fertilizer N and K is tested at sites with different heights.

Keywords: Utilization, fertilizer, Production, Yellow Manado Corn.

1. Introduction

Corn (*Zea mays* L) is the second food plant comodity after rice. Corn plant has sufficient nutrient and fiber content to be used as a substitute staple food. Corn contains 66.70% starch, 10% protein, 4.8% oil, 8.5% fiber, 3% sugar and 7% ash (Hokmalipur and Darbandi, 2011). Corn also contains various essential minerals, e.g. K, Na, P, Ca, and Fe. Genetic factors have strong influence on chemical composition and functional properties of corn. Given the importance of the nutrient content of corn, therefore, it needs to be considered by corn researchers, food industry practitioners, and stakeholders to raise corn not only in terms of production but also the nutritional quality and utilization (Suarni and Widowati, 2007).

The role of corn in North Sulawesi is very important. Besides as food for humans, corn are needed among ducks, horses, pigs and broilers breeder. Many communities in North Sulawesi lot less like hybrids corn which is available on the market because it is less tasty. Ducks breeders in Tondano even suggest that ducks feed made from hybrids corn makes them less productive and the lower the ability to lay eggs (Bahtiar *et al.*, 2010). Therefore, many people are looking for local maize that is cultivated by them with conventional technology.

Yellow Manado Local Corn is the type of the local corn which widely known in North Sulawesi community. According to Tamburian (2011), communities like Yellow Manado corn for the high rice yield and can be retained. Yellow Manado maize productivity is very low ranges 1-2 tons per acre at the farm level, the relatively long life of 110-130 days, the

plants is tall so easy to fall down if the wind blows, many grown on dry land under coconut trees, or yard with a relatively narrow area. Seeds that were planted is taken from the previous crop production so that the production ability continues to decline (Bahtiar *et al.*, 2010). In addition to the above, according to Puslitbangtan (2007), the low production of yellow Manado corn is due to the lack of downy mildew resistant (*Sclerospora maydis*).

The production of yellow Manado local corn in North Sulawesi Province continues to decline. In 2008 the production of yellow Manado corn produces 488,041 tons ha^{-1}, while in 2009 it produces 455,774 t ha^{-1}, or decreased by 8,267 tonnes ha^{-1}. The low level of productivity of maize is due to the level of soil fertility, climate, socio-economic conditions of society (Bahtiar *et al.*, 2010) and the use of improper farming techniques (Tamburian, 2011). Cultivation techniques that are applied by farmers are still the traditional way handed down from previous generations. Therefore it needs improvement efforts through adaptive technology and mutual synergism that can increase Yellow Manado corn production. The increase of yellow Manado corn production can be done through the technique and dosage as well as the right kind of fertilizer.

Fertilization aims to meet the total needs of the lack of appropriate nutrient in the soil, thus the production increases. The efficiency of fertilization should be done, because the excess or inaccuracy of fertilizing can adversely affect the plants and the environment and is a significant waste of enhancing inputs. The fertilizing should follow right six principles, i.e. the right amount, type, manner, place, time, and adapted to the nature/type of soil. In general corn plants absorb 23-34 kg of N, 6.5 to 11 kg of P_2O_5 and 14-42 kg of K_2O from the soil for each produced ton. In addition to the three macro nutrients, the other nutrients are also absorbed, e.g. 37 kg of Mg, 604 g of Mn and 519 g of Zn / ha.

Nitrogen fertilizer is an important nutrient for corn crops. Nitrogen has an important role in the formation of chlorophyll, where chlorophyll has a role in the process of photosynthesis (Hokmalipur and Darbandi, 2011). Koswara (1988) says that the corn crop takes N throughout its life. Nitrogen is absorbed by crops during the growing period until the maturation of seeds, so that the crop requires continuous availability of N at all stages of growth until the seed formation. Giving the right fertilizer for corn plant growth can increase the yield of corn (Lingga and Marsono, 2008).

Lands in Indonesia are generally lack of nutrient K, thus requiring additional fertilizer K. In North Sulawesi, the use of fertilizer K for crops by farmers has not been done. In general, farmers are more familiar with fertilizer N and P than fertilizer K, so that farmers rarely even never use fertilizers K in the farming business, and they do not understand the benefits of element of K (Tamburian, 2011). K is important in many physiological and metabolic processes, which regulate respiration, enzyme activity, protein synthesis and assist translocation of carbohydrates. K is a nutrient that is an absolute must have and is available in the soil for plant growth purposes. K needs increased if the use of fertilizer N and P is more and more acceptable for plants, because K also acts as a counterweight to the other elements.

2. Materials and Methods

2.1.Tools and Materials

Materials that will be used are yellow Manado varieties corn seed, Urea fertilizer, SP-36 and KCl, insecticides and fungicides Victory Diazinon.

The tools used are the meter rope, hoe, analytical scales, bags, plastic, oven, leaf area meter and High Performance Liquid Chromotography (HPLC).

2.2. Experiment design

The experiment was conducted using a group random design consisting of 2 factors: 1) urea fertilizer dose and; 2) KCl fertilizer dose that is repeated three times. The first factor is the dose of urea fertilizer that consists of 3 levels:

N_0 = 0 kg (without fertilizer)
N_1 = 150 kg ha^{-1}
The second factor is the dose of KCl (K) which consists of 3 levels:

Among two combinations it obtains 9 treatment combinations, i.e.:

N_0K_0 = control (without fertilizer)
N_0K_1 = Urea of 0 kg ha^{-1}, KCl of 50 kg ha^{-1}

Each treatment combination is repeated three times so as to provide treatment plots totaling 27 plots.

2.3.Experiment implementation

2.3.1. Soil cultivation and manufacture of plot

The soil is cultivated with plow 3 times (two times plow and harrow once) to acquire suitable structure of land for the growth of corn. Loose soil is leveled, while cleaning the grass or other materials that may interfere with the growth of the plant, and then made the plot that will be ready for planting. The plot size is 4 x 7 m, the distance between treatments is 1 m and the distance between replications is 1.5 m.

2.3.2.Planting

Seeds are planted in drill holes with a depth of 3 to 4 cm, the used spacing is 75 cm x 40 cm, and the number of seeds per planting hole.

2.3.3.Fertilization

Corn plants are fertilized with SP-36 at a dose of 100 kg ha^{-1}, as a basic fertilizer. KCl fertilizer with appropriate doses of each given treatment at planting. Urea fertilizer with appropriate doses of each treatment is given (1/3 at planting, and 2/3 parts at the 30 days old plants after planting). Fertilizer application at planting is placed approximately 10 cm from the planting hole. The application of fertilizer when planting is done and then closed, the second fertilizer application is done simultaneously and placed 10 cm from the plant.

3. Results

3.1.Result and Result Component

3.1.1.Weight of dry shelled Per Cob

The analysis results of variance show no significant interaction occurs at observation of dry shelled weight per cob due to urea fertilizer (N) and KCl fertilizer (K) treatment. Provision of urea and KCl fertilizer separately has significant effect on dry shelled weight per cob. The average weight of dry shelled per cob due to the urea treatment (N) and KCl (K) are presented in Table 1.

Table 1: Weight of dry shelled per cob (g) due to the treatment of Urea and KCl fertilizer

Treatment	Weight of dry shelled per cob
Urea fertilizer (N)	
N_0 (0 kg ha^{-1})	23.94 a
BNT 5%	2.18
KCl fertilizer	
K_0 (0 kg ha^{-1})	35.57 a
BNT 5%	2.18

Note: Numbers that are accompanied by the same letter indicate insignificant different at the LSD of 5%.

Table 1 indicates that the corn crop that is not fertilized with urea and KCl produces the lowest weight of shelled per cob compared with the provision of urea and KCl fertilizer. Urea doses increase to 300 kg ha^{-1} (N_2) produces the highest weight per crop of 48.64 g. KCl fertilizer application of 100 kg ha^{-1} (K_2) on shelled corn plants produce a higher weight than the dose of 50 kg of KCl ha^{-1} (K_1) in the amount of 43.42 g.

3.1.2 Weight of dry shelled Per Hectare

The results of variance analysis show no significant interaction occurs on dry shelled weight per hectare due to urea (N) and KCl (K) treatment. Provision of urea and KCl fertilizer separately affect significantly on the weight of dry shelled per hectare. The average weight of dry shelled per hectare due to urea (N) and KCl (K) fertilizer treatment are presented in Table 2.

Table 2. Weight of dry shelled per hectare (t ha^{-1}) due to urea and KLC fertilizer treatment

Treatment	Dry shelled weight
Urea fertilizer	
N_0 (0 kg ha^{-1})	1.60 a
KCl fertilizer	
K_0 (0 kg ha^{-1})	2.37 a

Note: Numbers that are accompanied by the same letter indicate insignificant different at the LSD of 5%.

In Table 2 it can be seen that the corn crop which is not fertilized with urea and KCl fertilizer produce the lowest weight of dry shelled per hectare (N_0 and K_0), compared to corn plants which are fertilized with Urea and KCl. Urea doses increase to 300 kg ha^{-1} (N_2) produces the highest dry shelled weight per hectare of 3.24 tons.

KCl fertilizer application of 100 kg ha^{-1} (K_2) on corn crops results the higher dry shelled weight per hectare than the dose of 50 kg KCl ha^{-1} (K_1), i.e. 2.89 ton^{-1}.

3.1.3.Weight of 1000 dry shelled seeds

The results of variance analysis shows significant interaction between urea (N) and KCl (K) fertilizer treatment of the dry weight of 1000 shelled seeds. The average weight of 1000 dry shelled seeds due to urea (N) and KCl (K) fertilizer are presented Table 3.

Table 3. Weight of 1000 seeds (g) due to the treatment of Urea and KCl fertilizer.

Urea (N) fertilizer	**KCl (K) fertilizer**		
	K0	K1	K2
N0	159.02 a	176.77 ab	182.19 b
BNT 5%		21.55	

Note: Numbers that are accompanied by the same letter indicate insignificant different at the LSD of 5%.

Table 3 shows the corn crop which is not fertilized (N_0K_0) resulted in the lowest weight of 1000 seeds, while the combined treatment of 300 kg of ha^{-1} urea and 100 kg ha^{-1} of KCl results the highest weight of 1000 seeds. KCl fertilizer application without urea (N_0K_1 and N_0K_2) fertilizer and urea fertilizer without KCl fertilizer (N_1K_0 and N_2K_0) results the lower weight of 1000 seeds than the corn plants which are fertilized with urea and KCl fertilizer (N_1K_1, N_2K_1, N_1K_2 and N_2K_2).

3.1.4. Seed Number per Cob

The results of variance analysis show significant interaction between urea (N) and KCl (K) fertilizer treatment on the seed number per cob. The average number of seeds per cob due to urea (N) and KCl (K) fertilizer are presented in Table 4.

Table 4. The number of seeds per cob of corn due to urea and KCl treatment.

Urea (N) fertilizer	**KCl (K) Fertilizer**		
	K_0	K_1	K_2
N0	128.80 a	138.52 ab	148.51 b
BNT 5%		16.44	

Note: Numbers that are accompanied by the same letter indicate insignificant different at the LSD of 5%.

Table 4 shows the application of KCl at 50 kg ha^{-1} (N_0K_1) can increase the number of corn per cob, but still not significantly different from non-fertilized corn plants (N_0K_0). The combination of N and K fertilizer at various doses can increase the number of corn per cob. Corn plants that are fertilized with N and K fertilizer at various doses (N_1K_1, N_1K_2, N_2K_1 and N_2K_2) produce higher number of seeds per cob than the corn that are only fertilized with N and K fertilizer (N_0K_1, N_0K_2, N_1K_0, and N_2K_0).

3.2. Quality of Seed Corn

3.2.1. Seed Corn Starch levels

The results of variance analysis shows significant interaction between urea (N) and KCl (K) treatment on the starch content of corn seed. Average of corn seed starch content due to the application of urea (N) and KCl (K) fertilizer are presented in Table 5.

Table 5. Levels of starch (%) due to the Urea and KCl treatment.

Urea (N) fertilizer	**KCl (K) fertilizer**		
	Ko	K1	K2
N0	30,35 a	33,30 a	39,69 b

Note: Numbers that are accompanied by the same letter indicate insignificant different at the LSD of 5%.

Table 5 shows that the application of KCl fertilizer of 50 kg ha^{-1} without N fertilizer results in lower starch content than other fertilizer applications and not significantly different from non-fertilized corn crop. The combination of N and K fertilizer can increase the starch content of the corn seeds, with a higher starch content obtained in the combined treatment of Urea 150 kg ha^{-1} + KCl 100 kg ha^{-1} (N_1K_2) and Urea fertilizer of 300 kg ha^{-1} + KCl 100 kg ha^{-1} (N_2K_2).

3.2.2. Total Sugar Levels

The results of variance analysis shows significant interaction between urea (N) and KCl (K) fertilizer treatment on the total sugar content of corn seed. The average of total sugar levels due to the application of urea fertilizer (N) and KCl (K) are presented in Table 6.

Table 6 Levels of total sugar (%) due to the treatment of Urea and KCl fertilizer.

Urea (N) fertilizer	**KCl (K) fertilizer**		
	K0	K1	K2
N0	2.44 a	2.58 a	2.77 a
BNT 5%		0.55	

Note: Numbers that are accompanied by the same letter indicate insignificant different at the LSD of 5%.

Table 6 shows that the application of KCl fertilizer on corn crop without urea fertilizer results in improvement of the lower seed corn sugar levels (N_0K_1 and N_0K_2), than when fertilized with N and K fertilizer (N_1K_1, N_1K_2, N_2K_1 and N_2K_2), or just fertilized with only urea (N_1K_0 and N_2K_0). Corn crops are not fertilized at all (N_0K_0) produces indifferent sugar levels from the corn plants that are only fertilized with K fertilizer (N_0K_1 and N_0K_2). The higher corn sugar levels are obtained on the corn crop which is fertilized with urea fertilizer as much as 150 kg ha^{-1} and 300 kg ha^{-1} in combination with KCl fertilizer of 100 kg ha^{-1} (N_1K_2 and N_2K_2).

3.2.3. Levels of Carotene

The results of variance analysis show significant interaction between urea (N) and KCl (K) fertilizer treatment on the carotene (Appendix 35). The average carotene due to the provision of urea (N) and KCl (K) fertilizer are presented in Table 7.

Table 7. Carotene content of corn seed (mg g^{-1}) as a result of urea and KCl treatment.

Urea (N) fertilzer	**KCl (K) fertilizer**		
	Ko	K1	K2
N0	0.43 a	0.83 b	0.94 b
BNT 5%		0.13	

Note: Numbers that are accompanied by the same letter indicate insignificant different at the LSD of 5%.

Table 7 shows that the corn crop which is not fertilized (N_0K_0) results in the lowest values of carotene compared with the fertilized corn crop. N and K fertilizer application can increase the carotene content in corn seeds. The highest carotene levels of seeds are obtained at the seed corn which is fertilized with 300 kg ha^{-1} of Urea + 100 kg ha^{-1} of KCl (N_2K_2), that is 2.03 mg / g.

4. Discussion

4.1. Effect of treatment on corn crops

The results of variance analysis show that the application of urea and KCl fertilizer separately, significantly affects on the results of shelled corn per plant and per hectare. The doses of urea and KCl increase improve the shelled yield per cob and per hectare. The increasing urea fertilizer dose to 300 kg ha^{-1} and KCl to 100 kg ha^{-1} results the highest weight of shelled per plant and per hectare. This is because to produce the high yield seeds, the quite high content of N and K element is required, considering the location of the research has low N and K element in the soil. N is an important element in the composing of leaf molecules that can increase the rate of photosynthesis, which increases the rate of photosynthesis will increase the accumulation of photosynthesis to seed thus increasing shelled weight per cob.

Potassium elements that are contained in KCl fertilizer play an important role in increasing the size and weight of seeds. According to Maruapey and Faesal (2010), potassium element plays an important role in the formation and translocation of carbohydrates.

The increase of urea fertilizer doses improves the shelled yield per cob and per hectare. Tables 1 and 2 show an increase in the dose of urea fertilizer to 300 kg ha^{-1} results in weight per cob and the highest shelled weight. These results are consistent with the results of research by Maruapey and Faesal (2010), which indicates that the higher N fertilization tends to increase the yield of corn, with the highest yield is obtained at a dose of 300 kg ha^{-1} of urea (138 kg of N). It is closely related to the increase in leaf area index and net assimilation rate of plants. Tables 3 and 4 show an increase in urea fertilizer dose increase leaf area index and net assimilation rate of plants. The increase in leaf area index, or in other words, the increase of the leaf surface area per unit will increase the efficient use of sunlight during photosynthesis process so that the amount of carbohydrate that is formed in the plant tissue will increase. Carbohydrates will then be distributed to all parts of the plant to stimulate the growth and development of corn cobs and seeds, so the shelled yields per cob and per hectare to increase.

The KCl increase improves corn seed weight per cob and per hectare. Element K plays important role in increasing the size and weight of seeds, as required in the formation and translocation of carbohydrates that are required for the formation of generative organs. The research results show that KCl fertilizer application of 100 kg ha^{-1} results in the highest shelled weight per cob and per hectare. This is presumably because the dose may provide an element K that is sufficient to smooth translocation and formation of carbohydrates that are required for growth of the generative organs thereby increasing the crop weight per cob and per hectare. These results are consistent with the results of research by Maruapey and Faesal (2010) which shows the application of KCl of 100 kg ha^{-1} results the higher corn seed yield per hectare.

The Urea and KCl doses increase results in a higher weight of 1000 seeds. The results show that the dose combination of 300 kg urea ha^{-1} and 100 kg ha^{-1} KCl (N_2K_2) generates the highest weight of 1000 seeds. This is consistent with the increase in leaf area that serves as the photosynthesis process. Urea fertilizer dose of 300 kg ha^{-1} and KCl of 100 kg ha^{-1} (N_2K_2) result the high leaf area and chlorophyll so that an increase in photosynthate become more. According to Mapegau (1998), the sink intensity on cereal crops can be improved by administering K. The KCl dose increase which is offset by an increase in the dose of urea causes the physiological processes of plants run better. This is because the role of the element K as an enzyme activator is essential in physiological reactions cause the accumulation rate of photosynthate runs optimally so that it produce heavier crop biomass (Maruapey and Faesal, 2010).

Corn plants that are not fertilized or only fertilized with KCl produce low 1000 seeds weight and seed number. This is because nitrogen has very important role in the growth and yield. The unavailability of nitrogen causes low weight per cob and per hectare. These results are consistent with the research results by (Maruapey and Faesal, 2010).that the plants which are not fertilized with N produce the lowest seed yield per hectare and the lowest weight of 1000 seeds. Further explained that nitrogen deficiency in plants will show symptoms of yellowing of the leaves, seeds shrivel and low fruit weight.

Efficient use of sunlight determines the weight of corn kernels. This is because the grain size depends on the factors that control the supply of assimilates for grain filling. Corn plants that are fertilized with 300 kg ha^{-1} of urea and 100 kg ha^{-1} of KCl (N_2K_2) produces higher leaf area and leaf chlorophyll, so the photosynthesis process run more effectively. The effective photosynthesis process increases the accumulation of photosynthate. According to Maruapey and Faesal (2010), the higher the yield of photosynthesis, the greater the accumulation of food reserves are translocated to the seed. Therefore, the plants which are fertilized with 300 kg ha^{-1} of urea and 100 kg ha^{-1} of KCl (N_2K_2) generates the highest weight of 1000 seeds and not too much number of seeds (Tables 3 and 4), which shows a large weight per seed. The high weight of 1000 seeds generates the high weight per cob and high weight per hectare as well.

4.2. The Effect of treatment on the quality of corn seed

The Urea and KCl fertilization can improve the quality of yellow Manado local maize. The best corn quality is obtained in the combination treatment of 300 kg ha^{-1} of urea and 100 kg of ha^{-1} of KCl (N_2K_2). This is due to the low levels of N and K elements on the research soil location, so as to produce a good quality corn it requires additional urea and KCl fertilizer in considerable amounts. Tables 5, 6 and 7 show that the

application of 300 kg ha^{-1} of urea and 100 kg ha^{-1} of KCl (N_2K_2) produces the highest sugar, starch and carotene. K fertilization which is offset by N in a sufficient amount would help to make a better quality of maize seed. According to Haris and Krestiani (2004), potassium is needed in the formation process of sugars and starches, sugar translocation, enzyme activity and stomata movement. Increase in weight and sugar content in corn kernels can be performed by streamlining the process of photosynthesis in plants and improving the photosynthate translocation to the cob.

The KCl application can improve the quality of maize seed. According to Mapegau (1998), K can increase the sucrose content. The results shows that the increase of KCl fertilizer doses that is offset by increasing the N doses, produces starch, sugar and carotene. Sugar levels increase with the increase of potassium fertilizer application. The sugar levels are closely related to the formation and use of carbohydrates. The addition of K elements results in increase of leaf areas and high chlorophyll content, so that the process of photosynthesis can run better and produce more carbohydrates. It increases levels of starch, sugar and carotene in the corn kernels.

Yellow Manado corn plants which are not fertilized or only fertilized with KCl produce low quality maize seed. Potassium physiologically has function in shaping and transporting carbohydrates, when plant has K deficiency will, it will decrease the accumulation of carbohydrates which results in decreased levels of starch and sugars in the seed. Although elements K can improve the quality of maize seed, the application of K without being offset by the application of urea causes low seed quality. This is because nitrogen is needed in the process of photosynthesis. Photosynthesis produces carbohydrates from CO_2 and H_2O, but the process cannot take place without producing proteins, nucleic acids and etc, if N is not available.

Conclusions

1. The effect of Fertilizer Urea (N) and KCl (K) on growth, yield and quality of Yellow Manado Local Crop indicates that the plants which are not fertilized grow and produce less yield than the crops which are fertilized with KCl.
2. Application of urea and KCl increase the growth and yield of corn. Urea-dose combination of 300 kg ha^{-1} + KCl 100 kg ha^{-1} results in the highest growth and yield of corn. Urea-dose of 300 kg ha-1 results in the highest dry shelled yield weight per hectare of of 3.24 t ha^{-1}, a KCl-dose of 100 kg ha^{-1} results in dry shelled weight of 2.89 t ha^{-1}. Urea-dose combination of 300 kg ha^{-1} + KCl 100 kg ha^{-1} results in the highest carotenoid and sugar content, respectively: starch of 65.10%, sugar and carotene content of 5.37% 2.03 mg/g.
3. The combination of the use of 300 kg ha-1 urea and 100 kg ha-1 KCL, as well as cultivated and nurtured land as much as 2 times at 15 and 45 days after planting and at planting 3 times, 30 DAT and 45 DAT results the highest growth, yield, nutritional quality.

References

Bahtiar, J. Sondakh dan A. Tenrirawe. 2010. Analisis Usahatani Beberapa Varietas Unggul Baru Jagung Komposit di Sulawesi Utara. Prosiding Pekan Serealia Nasional. p.490-495.

Mapegau F. 1988. Karakteristik Tanaman Jagung. Balai Penelitian Tanaman Pangan Bogor. p. 33 – 48.

Haris, A dan V. Krestiani, 2010. Studi Pemupukan Kalium terhadap Pertumbuhan dan Hasil Jagung Manis (*Zea mays saacharata* Stuart) Varietas Super Bee. Fakultas Pertanian. Universitas Muria Kudus. p. 1- 5.

Hokmalipur, S. dan M.H. Darbandi. 2011. Effect of Nitrogen Ferlizer on Chlorophyll Content and Other Leaf Indicate in Three Cultivar of Maize (*Zea mays* L.). World Applied Sciences Journal. 15 (2) : 1780-1785.

Koswara, J. 1988. Tanaman Jagung. Departemen Agronomi Fakultas Pertanian IPB. Bogor.

Lingga, P dan Marsono. 2008. Petunjuk Penggunaan Pupuk. Penebar Swadaya. Jakarta. 150 hal.

Puslitbangtan. 2007. Deskripsi Jagung Varietas Manado Kuning. Pangan. Litbang.Deptan.go.id. Diakses tanggal 19 Februari 2011.

Suarni dan S. Widowati. 2007. Struktur, Komposisi dan Nutrisi Jagung. Jagung : Teknik Produksi dan Pengembangan. hal : 410 – 426..

Maruapey, A dan Faesal, S. 2010. Pengelolaan Hara pada Tanaman Jagung. Balai Penelitian Tanaman Serealia, Maros. p. 205-218.

Tamburian, Y. 2011. Usahatani Jagung di Lahan Kering dengan Pendekatan Pengelolaan Tanaman Terpadu di Kabupaten Minsel. Seminar Nasional Serealia. p. 325-336.